Seapilot

AUTOMATIC PILOTS

TECHNICAL MANUAL

SHARP

Seapilot

AUTOPILOT

TECHNICAL MANUAL

3 Edition

SHARP & COMPANY LTD

Telephone: SANDWICH 3206/7/8
Telex: SHARPCO SANDWICH 96308

RICHBOROUGH HALL
SANDWICH
KENT ENGLAND

INTRODUCTION

AUTOMATIC PILOT. Steering an accurate course calls for a high degree of seamanship, a tiring job that requires constant alertness to detect small changes of compass heading, then the immediate correct amount of rudder has to be applied to bring the craft on course without over or understeer. This function can be performed automatically providing certain control functions are designed and built into the Automatic Pilot, these functions, because of simplicity and cost, are manually adjusted to suit the type of craft, speed, wind, seas and other factors. However, the Automatic Pilot that you are about to install with the help of these instructions has been designed for you to install, without previous experience, understand and give you better boating.

DRIVE UNITS. A range of drive units are available so that you may choose the optimum for your boat with regard to power output and economy.

FUEL SAVING

With todays high fuel costs it is more important than ever that the course steered is as short and therefore as straight as possible. Only with a consistently accurate Auto Pilot can the optimum in fuel economy be achieved.

SUITABILITY

Mechanically steered vessels of up to 70 feet overall length can be accommodated with Seapilot range although due to mechanical life considerations, we would not recommend that mechanically steered work boats in excess of 40 feet overall are suitable for this model of Auto Pilot.

Hydraulically steered vessels of almost any length can be catered for by the use of a spool valve system. For smaller hydraulic installations, the MD3 drive unit with its reversible pump provides adequate steering power.

BATTERY CONSUMPTION

The question of battery consumption has been carefully considered. On an average 12 volt system the consumption is approximately 2 ampere hour. It can be less by careful attention to sail trim and for those craft that sail themselves. A 65 ampere hour battery would be discharged by 20 amperes for 10 hours non-stop sailing. To re-charge, the motor would have to be run for around 2 hours, charging at 15 amperes. When motoring or motor sailing, the current required in relation to the normal charging rate of the dynamo or alternator is very small and does not affect the other requirements of the duties of the battery for the vessel.

Our Auto Pilot is designed for owner installation: the equipment requires no maintenance apart from being kept clean of salt water corrosion by cleaning with fresh water at regular intervals. We hope with this manual, you will be able to fit the units without difficulty. Once fitted, we know you will be delighted with the performance and wonder how you ever managed without your Mate Auto Pilot.

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DESCRIPTION OF UNITS

SCU11 CONTROL UNIT - Attractively styled and designed for ease of operation, provides the following controls: Yaw, Rudder, Trim and Left/Right Course change. Incorporates Port and Starboard lights, to visually indicate Pilot operation, and Remote Control connector. The Control Unit is supplied with a universal tilt bracket for chart table, bulkhead or overhead mounting or alternatively can be flush mounted.

A60 BINNACLE UNIT - This precision, fully gimballed instrument incorporates a patented polaroid sensing system which will detect the slightest deviation from the desired course. It features automatic alignment with the ship's head for course setting with Control Unit switched to Standby and 360° course memory. To operate Seapilot, steer the boat onto the desired course and then switch from Standby to Duty. Adjustable built-in magnetic compensation and weatherproof construction permits the Binnacle Unit to be mounted anywhere away from local interference.

SDU1 DRIVE UNIT - 12 or 24 volt suitable for vessels of up to 45 feet (15 m) LOA with mechanical steering systems.
It provides 20 lbs.ft. output torque at 20 r.p.m., can be connected via either sprocket and chain or rack and pinion to the ship's steering system, and features an automatic electric dutch operated from the Control Unit.

SDU2 DRIVE UNIT - 12 or 24 volt suitable for vessels up to 70 feet LOA with mechanical steering systems. It provides 35 lbs.ft. at 20 r.p.m., can be connected via either sprocket and chain or rack and pinion to the ship's steering system, and features an automatic electric clutch operated from the Control Unit.

MD3 DRIVE UNIT - 12 or 24 volt suitable for vessels having hand hydraulic steering systems with steering cylinder capacities up to 18 cu.ins. (300 cu.cms). Provision is made for alteration of the pump output by selection of pump pulley to suit the cubic capacity of the particular steering ram. The MD3 must be used in conjunction with the MF Feedback Unit.

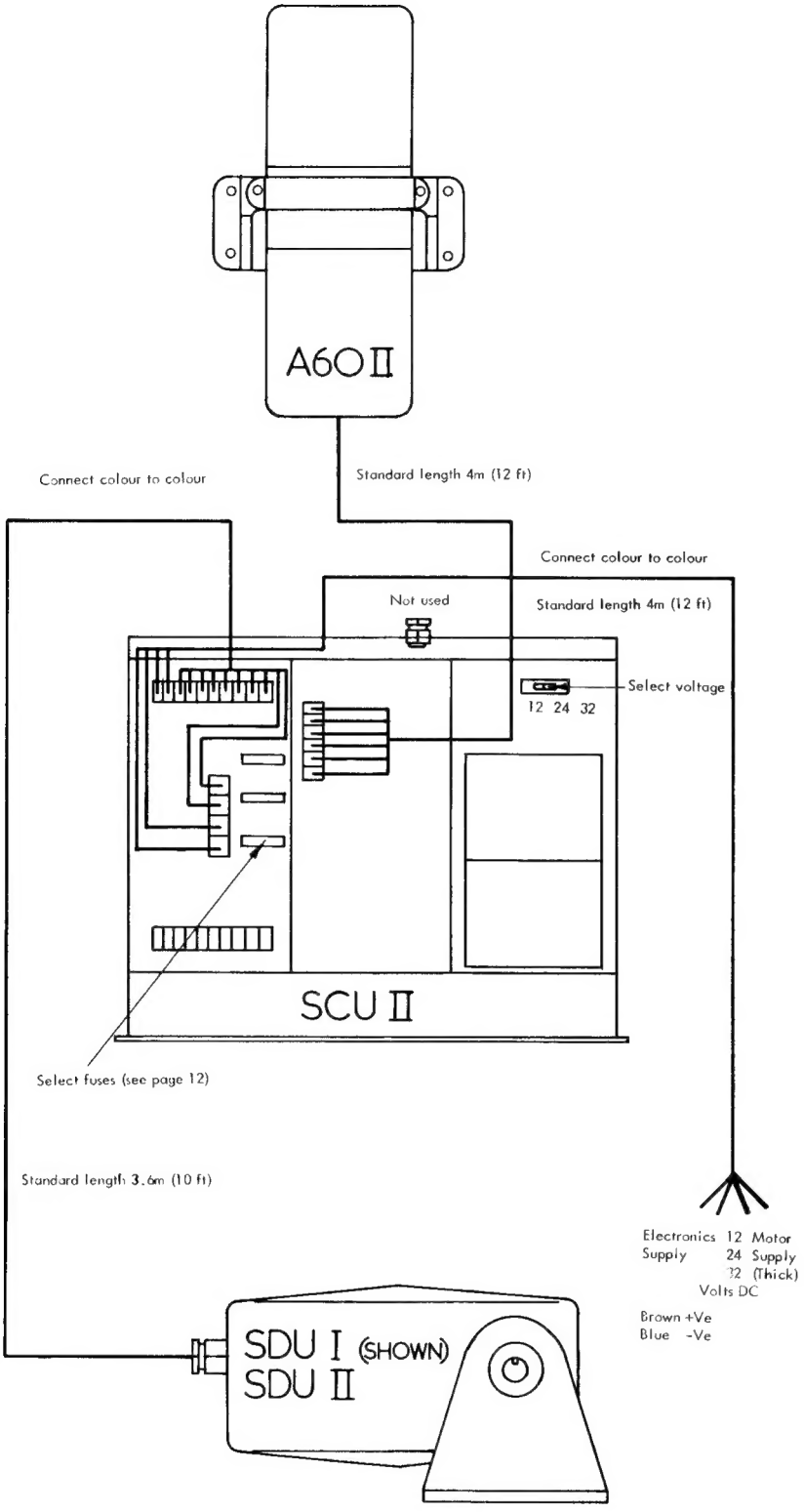
MF FEEDBACK UNIT - Used in conjunction with the MD3 Drive Unit, it provides the signal sensing electronics with rudder position information. It is connected directly to the rudder.

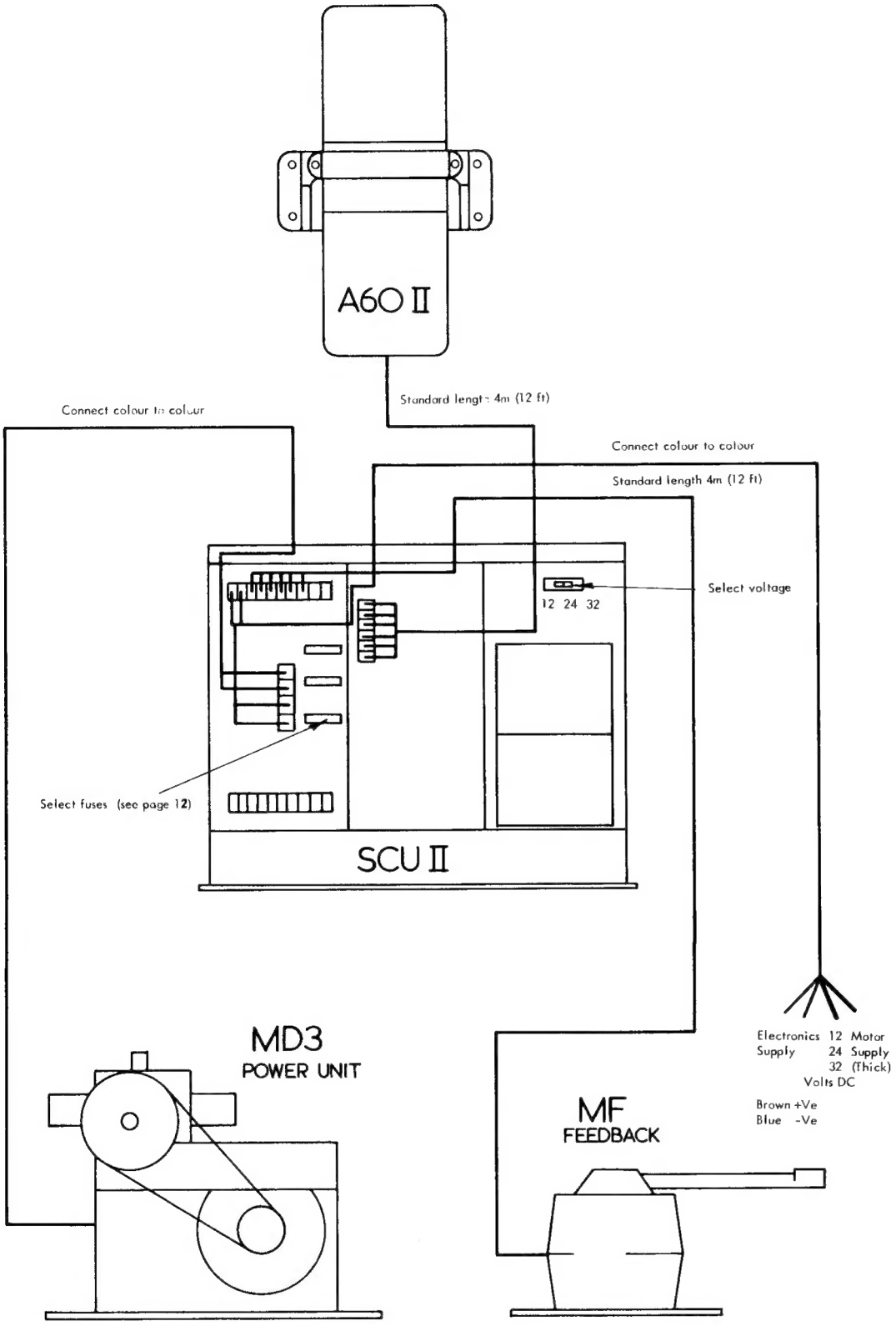
RACK DRIVE - Enables the Drive Unit to be connected directly to the rudder, tiller bar or quadrant.

RSC REMOTE STATION CONTROL - Mounted near to the vessel's second steering position, e.g. flying bridge, this unit enables the helmsman to make course alterations by depressing the Left/Right switch or to steer the vessel manually, by depressing the On/Off to Off. Auto-Pilot steering is re-established by depressing the On/Off switch to On, a lamp indicates when the Auto-Pilot is engaged. Connected to the Control Unit via the RSRB.

RSRB REMOTE STATION RELAY BOX - Used in conjunction with the Remote Station Control, inter-unit cables are rerouted through this unit, as shown on page 7. It may be mounted out of sight in any convenient position.

SHR REMOTE CONTROL UNIT - A hand-held Unit that provides the helmsman with a power steering facility when switched to Manual. Switching back to Auto, the vessel will resume its original set course. The Unit plugs into the front panel of the Control Unit.


A60 II
Connect colour to colour
Standard length 4m (12 ft)
Connect colour to colour
Not used
Standard length 4m (12 ft)
Select voltage
12 24 32
SCU II
Select fuses (see page 12)
Standard length 3.6m (10 ft)
Electronics 12 Motor
Supply 24 Supply
32 (Thick)
Volts DC
Brown +Ve
Blue -Ve
SDU I (SHOWN)
SDU II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Connect colour to colour
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SCU II
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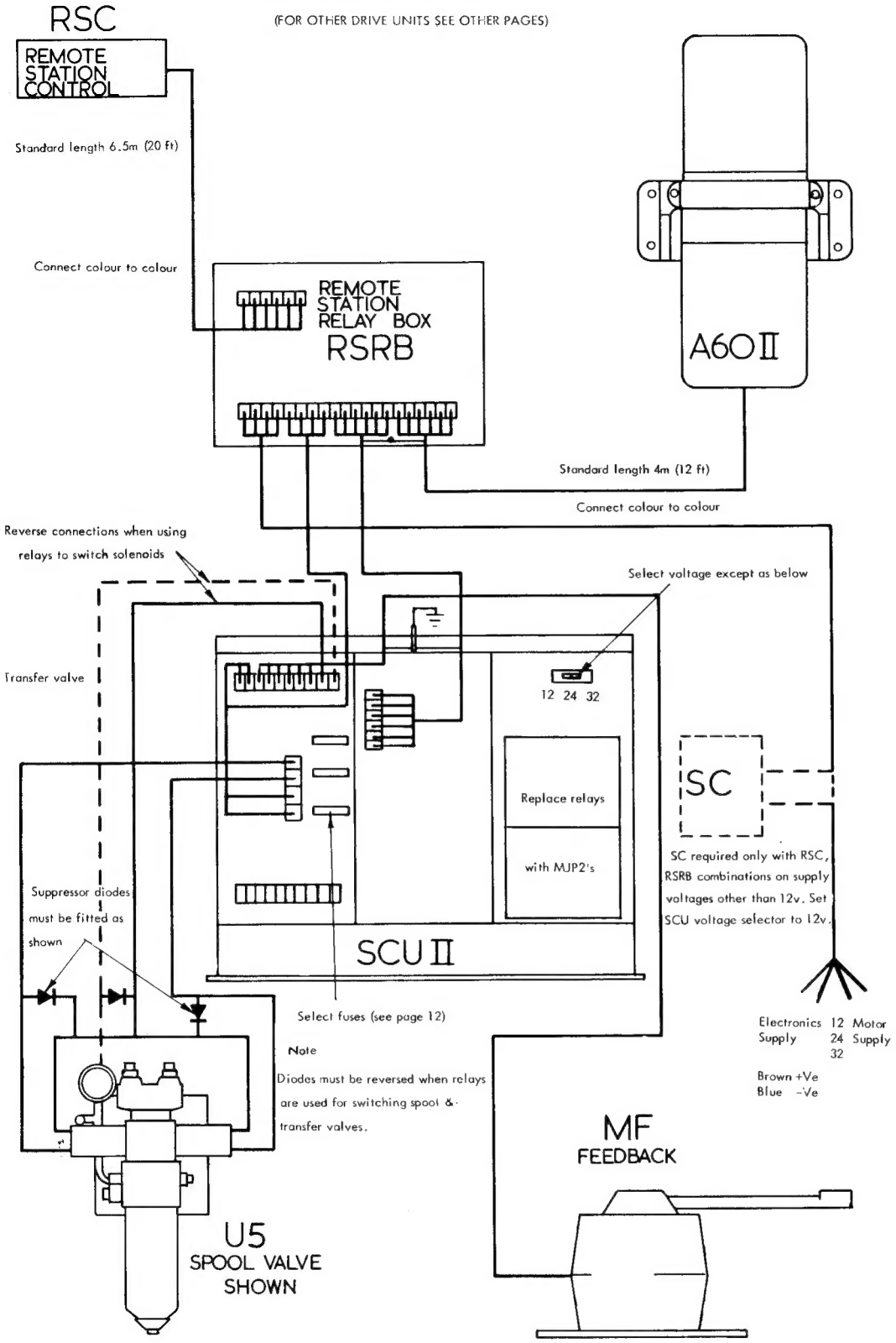
POWER UNIT
MF
FEEDBACK
Electronics 12 Motor
Supply 24 Supply
32 (Thick)
Volts DC
Brown +Ve
Blue -Ve

INTERCONNECTION DIAGRAM RSC & RSRB

SHOWING ALSO CONNECTIONS TO SPOOL VALVES

(FOR OTHER DRIVE UNITS SEE OTHER PAGES)



A60 11 BINNACLE INSTALLATION

To decide on the location of the Binnacle Unit, due account must be taken of the magnetic safe distances of the other Units of the Auto Pilot, as detailed below. It is therefore IMPERATIVE to decide on the positions of all the other units before deciding where to place the Binnacle.

SAFE DISTANCES TO AVOID INTERFERENCE

UNIT		
	Control Unit	4 ft.
	Steering Unit - Mechanical	5 ft.
	Remote Relay Box	4 ft.
	Remote Station Control	3 ft.
	Steering Unit - Hydraulic	5 ft.
	Spool Valve	4 ft.
	Hand Remote Control	NIL

The Binnacle is a compass and must be mounted free from magnetic interference in the same manner as a normal compass that would be used for navigation purposes. If this is not possible, a position must be found that is "Correctable" by a Compass Adjuster. The most convenient way of checking the proposed siting of the Binnacle is with a Hand Bearing Compass.

NOTE: Although the Binnacle cannot be observed and therefore used for navigation, the question is often asked "Why is it necessary to correct it?". The reason is that the automatic steering will be adversely affected if the location of the Binnacle is not in a magnetically free place. An error from magnetic North of not more than 10° on any course is allowable and correction is not required. Remember, one corrects the place the Binnacle is placed in, not the Binnacle. It follows that a hand bearing compass held in the place where the Binnacle is to be mounted, and that place corrected by observing the hand bearing compass, it will be correct for the Binnacle.

Providing the location of the Binnacle is magnetically correct (see above), it can be mounted at any convenient place, i.e. in a locket, cupboard, bulkhead, even on a mast (sometimes necessary to overcome the interference found on steel vessels). The ideal place is in the centre line of the vessel and as near the centre of movement of the vessel as possible. Free from vibration and within the standard cable length of 12 ft. of cable supplied that has to go to the Control Unit. As the Control Unit will be in the wheelhouse, the Binnacle can usually be conveniently mounted within this area, most likely below the wheelhouse deck level.

The Binnacle must be mounted vertically by means of the mounting bracket with four screws or nuts and bolts of 3/16" diameter. The bracket does not have to line up fore and aft because the Binnacle is rotatable within the clamp on the bracket and it is rotated so that the lubber line is pointed forward on the fore and aft line of the vessel and then clamped to secure. Make sure enough room is left above and below the Binnacle to enable the top and bottom covers to be removed.

BINNACLE OPERATIONAL CHECK

The Binnacle, when connected to the Control Unit, may readily be checked for operational function as follows:

Remove top Binnacle cover, which is held by 3 screws, so that the Binnacle card can be observed. Remove the Binnacle compass bowl protection clamp.

Switch the Control Unit Yaw knob from OFF to any position and Standby/Duty switch to Standby. The Binnacle card will now be driven by the Binnacle motor to seek magnetic North. It may be deflected by a magnetic influence such as a screwdriver, the same as a normal compass. If it does not function correctly, i.e. seek North and readily deflect with a magnetic influence, see section 'Trouble Shooting Binnacle'.

NOTE: Remember to remove Binnacle Compass Bowl protecting clamp. See that the clamp is left on board so that the Binnacle can be removed safely should it be necessary.

BINNACLE SPEED SETTING

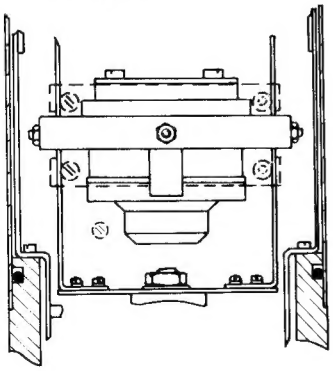
The speed at which the Binnacle rotates when the Left/Right switch of the Control Unit or Remote Station Control is depressed with the Auto Pilot switched to Duty, can be adjusted by a preset on the Binnacle Motor printed circuit board. Access to this preset is achieved by undoing the cable gland and three fixing screws of the bottom cover and withdrawing it from the Binnacle over the cable. The position of the preset is shown below.

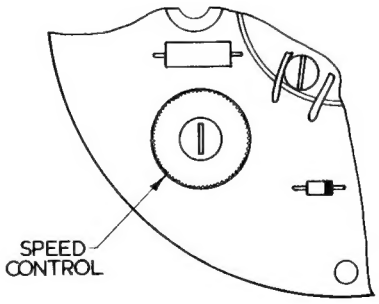
The speed at which the Binnacle rotates when making Left/Right course alterations must not be faster than a comfortable rate of turn for the vessel. If it is too fast the vessel will be unable to keep up with the rate of turn of the Binnacle and will progressively lag behind, so that when the Left/Right switch is released, the vessel will continue to turn until it has made up the difference.

The correct setting of the preset is best accomplished by trial and error. Find a clear stretch of water where the vessel can be turned at normal speed with safety. Rotate the preset fully clockwise to give the fastest Binnacle speed, operate the Left/Right switch and release when the boat has turned about 30-40 degrees and note how far the vessel overshoots, rotate the preset anti-clockwise a little and try another turn noting overshoot, continue until overshoot is acceptable: i.e. less than 5°.

The bottom cover may now be re-fitted and the cable gland tightened.

Before refitting the top cover the Binnacle compass correction procedure should be carried out as detailed opposite.





BINNACLE COMPASS CORRECTION

The Binnacle is driven by a small electric motor and, when connected to the terminals in the Control Unit, power is to the electronic supply and the Control Unit switched to Standby, the motor will drive the Binnacle to magnetic North. It follows that normal compass correction procedure can be carried out under these conditions. The Binnacle has built into it magnetic correction system and a procedure of correction for deviation is recommended as follows:

Remove the top cover of the Binnacle by means of the two screws which are underneath the rubber sealing band. Remove the bowl gimbal clamps (these are there for shipment). Completely remove the clamps by undoing the two nuts and screws that secure them.

CORRECTION FOR 'A' ERROR. Before correction for deviation can be made, it must be known that the Binnacle lubber line is correctly clamped in the fore and aft line of the vessel, so that when the card is read off it will read correctly. This is best undertaken as follows. The vessel is swung on to the eight cardinal points and the reading of the Binnacle card noted when it comes to rest.

EXAMPLE 1

Steering Compass	Sensing Unit	More +	Less -
000	358		2
045	040		5
090	082		8
135	126		9
180	185	5	
225	231	6	
270	274	4	
315	316	1	
		16	24
			16
			8) 8
			1 Less

EXAMPLE 2

Sensing Unit	More +	Less -
003	3	
051	6	
100	10	
147	12	
183	3	
220		5
267		3
313		2
	34	10
	10	
	8)24	
	3 More	

In Example 1 above, the 'Less' readings exceeded the 'More' by 8 - an average of 1, therefore the card reading should be increased by 1.

In Example 2, the 'More' readings exceeded the 'Less' by 24, an average of 3, therefore the card reading should be decreased by 3.

Adjustment to the card is made as follows. Switch to Off at the Control Unit, hold the compass bowl firmly with one hand, taking the backlash or slack up one way from the motor gears (usually about 2°), slacken the screw in the centre of the card and rotate the card by the required amount, re-tightening the screw. Do not attempt to hold the Compass Unit by the card, as the setting may be disturbed.

The table will now read as follows:

Example 1				Example 2		
Steering Compass	Sensing Unit	More +	Less -	Sensing Unit	More +	Less -
360	359		1	360		
045	041		4	048	3	
090	083		7	097	7	
135	127		8	144	9	
180	186	6		180		
225	232	7		217		8
270	275	5		264		6
315	317	2		310		5
		20	20		19	19

As will be seen, the 'More' and 'Less' errors are now equal.

Steer or swing the vessel to magnetic North and if an error reads on the Binnacle card, it is adjusted by rotating the screwdriver slot in the corrector magnet mounting rod (this is the rod that is lying athwartships, i.e. the screw slot is to starboard and port). When the magnetic rod slot is horizontal, no correction has taken place. Rotate the rod in either direction until the card reads North.

Steer on magnetic East and adjust the Binnacle card in the same manner by rotating the corrector magnet rod which lies in the fore and aft line, i.e. the screw slot is to the bow and the stern.

Steer on magnetic South (180°), any error shown on the card should be halved by adjustment of the magnetic corrector rod screw that is in the athwartships line.

Steer on magnetic West (270°), any error shown on the card should be halved by adjustment of the magnetic corrector rod screw that is in the fore and aft line (if the halved errors shown on the compass card cannot be corrected completely, a deviation table should be made, but this is not usually necessary; as stated before, we want the Binnacle corrected within 10° and this is readily achievable, except on steel boats.

NOTE: No provision has been made within the Binnacle for heeling error correction. Because of the unrestricted location of the Binnacle, a location free of heeling error can usually be found. Should this not be possible, the corrector magnet will have to be mounted above or below the Binnacle, with a suitable bracket to allow the Binnacle top or lower cover to be removed.

CONTROL UNIT INSTALLATION

The siting of the Control Unit should be given careful consideration bearing in mind the compass safe distance of 4 ft. (as explained on page 8).

The site should be chosen so that it is readily accessible from the steering position and the steering compass can be observed when operating the controls. The unit should also be mounted within the range of the SDU1 and SDU2 Drive Unit cables supplied of 12 ft. (4 metres). The MD3 hydraulic Drive Unit is not supplied with a cable, therefore the distance to the Control Unit is not critical.

The Unit can be chart table, bulkhead or overhead mounted inside the wheelhouse, with the universal tilt bracket supplied. If it is necessary to mount the unit outside in the cockpit, it must be waterproof and therefore panel mounted, as the unit is completely waterproof from the front panel. It is advisable to use Mastic to join the Control Unit front panel to the console. An aperture $8\frac{3}{4}$ inches (22.5 cm) by $4\frac{1}{2}$ inches (11 cm) must be cut in the panel to receive the Control Unit which is $8\frac{1}{2}$ inches (22 cm) deep. The case tube can be used as a template to mark out the aperture.

CABLE ENTRIES

The cables from all the other units terminate in the Control Unit as shown on pages 5-7 and are wired colour to colour.

Before wiring the Unit it is advisable to set the voltage selector switch to the vessel's supply voltage (except as on page 7) and insert the correct fuses as shown in the table below.

The Drive and Electronics supply must be wired separately to avoid voltage drop, caused by high motor current, affecting the electronics.

Cable sizes should be as follows:

DRIVE	CABLE SIZE
SDU1, SDU2, MD3	
Electronics supply	0.6 sq.mm. 16/0.20 mm. (14/.0076 in.)
Drive supply	1.50 sq.mm. 30/0.25 mm. (40/.0076 in.)
SPOOL VALVE	
Electronic supply	0.6 sq.mm. 16/0.20 mm. (14/.0076 in.)
Drive Supply	0.75 sq.mm. 24/0.20 mm. (23/.0076 in.)

Note that the Unit is polarity conscious and that the Brown wire is +ve and the Blue -ve. The Unit is protected against reverse polarity to avoid damage to the circuits.

FUSES	AMPS		
DRIVE	12 volt	24 volt	32 volt
SDU1	15	15	15
SDU2	25	15	15
MD3	25	15	15
SPOOL VALVE	3	3	3
ELECTRONICS	1	1	1

The Drive and Electronics supply must be wired separately to avoid voltage drop.

DRIVE UNIT INSTALLATION

The Mate Drive Units consist of a 12, 24 volt permanent magnet motor mounted to a suitable gearbox to give an output shaft speed of approximately 20 r.p.m. The output shaft for both types is as follows:

SDU1	20 r.p.m.	20 lbs.feet torque
	Stall	35 lbs.feet torque
SDU2	18 r.p.m.	35 lbs.feet torque
	Stall	60 lbs.feet torque

With the motors stalled a direct pull of 350 lbs. for the SDU1 and 600 lbs. for the SDU2 on the chain with a 13 tooth sprocket fitted to the output shaft. This pull must be taken into account when mounting the motor.

The Drive Units are grease lubricated so they may be mounted in any attitude.

Due to magnetic interference the Drive Units must not be sited near to magnetic compasses: the compass safe distance is 4 feet permanent and 5 feet intermittant. Therefore to avoid all interference the Drive Unit must be mounted at least 5 feet from the compass.

The MD1 & MD2 are supplied with approximately 1 metre of clutch cable which is simply attached to the Drive Unit on installation. The ideal position for this control is adjacent to the wheel so that the clutch can be disengaged quickly in an emergency and steering taken over manually. Fitting is shown on page 15.

Should it not be possible to connect the Steering Unit to a rotating shaft, a Rack Drive may be used to directly push and pull the rudder, tiller bar or quadrant (see chapter Rack Drive). The type of steering with a centre column and a Binnacle mounted on the top has no room usually to take another sprocket. In this situation the Rack Drive is the solution.

Adjustment must be provided to adjust chain tension, half inch pitch chain must be used, therefore an adjustment of half an inch is required, or a quarter of an inch if half chain links are to be used.

The performance of the Automatic Pilot must always be dependent on the amount and speed of rudder movement, which in turn depends on the power available to move it. It is most likely that you are fitting our SEAPILOT Drive Unit to your own boat and you are already familiar with how well or badly she steers. Try and estimate the largest rudder angle you have to put on for the worst sea and wind conditions and how quickly this rudder angle has to be applied. The Drive Unit shaft must move the rudder by at least this amount whilst being turned through 5 revolutions by the Drive Unit. On small boats the rudder may be moved fully (70°) by the Pilot; on larger boats the 5 turns of drive must move the rudder by less than the full rudder movement.

In other words, the larger the craft, the slower the speed of rudder movement and the smaller the total amount of rudder the Pilot is able to apply.

With wheel steering, the chain sprocket ratio cannot readily be altered. This is because the chain sprocket of the steering shaft has to be bored and keyed to suit the shaft on your boat. Its selection must, therefore, have careful attention to get it right first time.

As the drive motor power is fixed, you must expect that the effectiveness of the Pilot will change for different lengths of vessel. Our experience shows that the following can be expected, providing our controls are adjusted correctly and the installation is according to our recommendations. This applies to motor, motor sailing and sailing vessels. PERFECT steering means better than the best helmsman, FAIR means as good as, POOR worse than and NOT SUITABLE means the Drive Unit has not enough power.

NOTE: The STEERING UNIT has fitted inside, geared to the output shaft, the potentiometer of the Feedback and Limit Switches. The Limit Switches are not adjustable. They operate when the output shaft makes 5 turns. They can travel beyond the 5 turns without any harm. It is, therefore, important to remember that the output shaft must always be geared to make 5 turns before the rudder reaches the limit of its travel, full left to full right.

When the Drive Unit is in place, the chain should be fitted and the tension adjusted. With the clutch disengaged check that there is no resistance when the wheel is rotated.

The chain must now be removed and the Drive Unit wired as shown on page 5 , then centred by the following procedure.

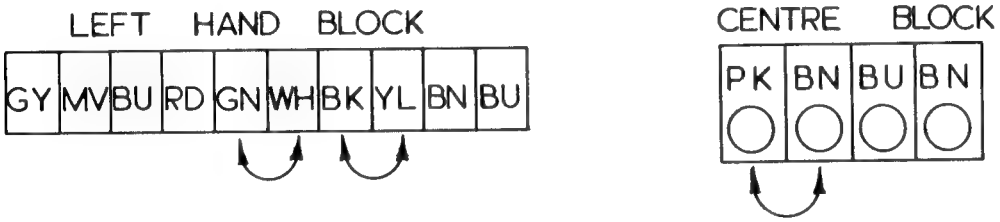
Ensure vessel tied up and unable to turn.

1. Switch Control Unit to STANDBY.
2. Centre TRIM and rotate RUDDER and YAW controls fully clockwise.
3. Switch Control Unit to DUTY when lamps are balanced and allow Drive Unit to drive until it stops. It is now centralised.
4. Put wheel to amidships and turn OFF Control Unit.
5. Connect chain or rack, taking care not to turn Drive Unit shaft.

Motor Direction

With the Drive Unit connected, check that the wheel rotates in the same direction as the TRIM control when the control is rotated.

If not, the following wires on the lower terminal block should be reversed.



CLUTCH CABLE CONNECTION

MD1

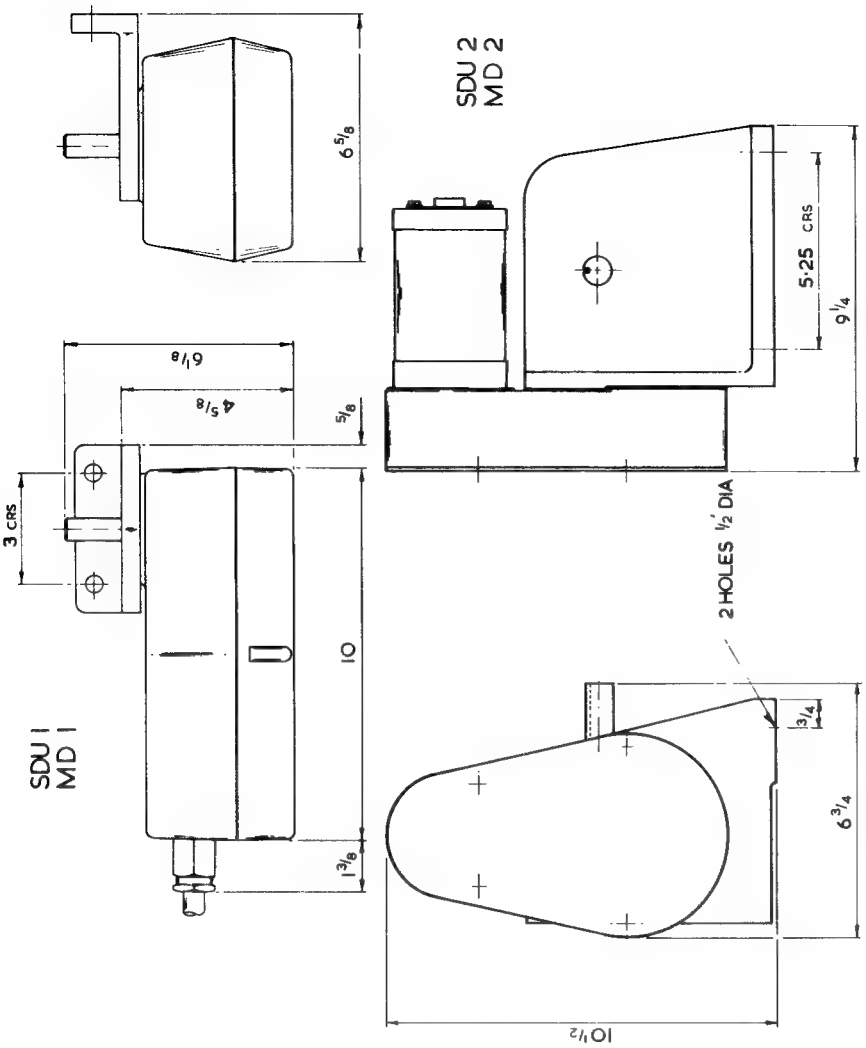
To connect the clutch cable, the Drive Unit lid must be removed by undoing the six screws with the Allen Key provided. Be careful not to damage the gasket which is stuck to the lid. The two screws holding the fixing clamp and the two grub screws in the fixing block (with Allen Key provided) should be loosened.

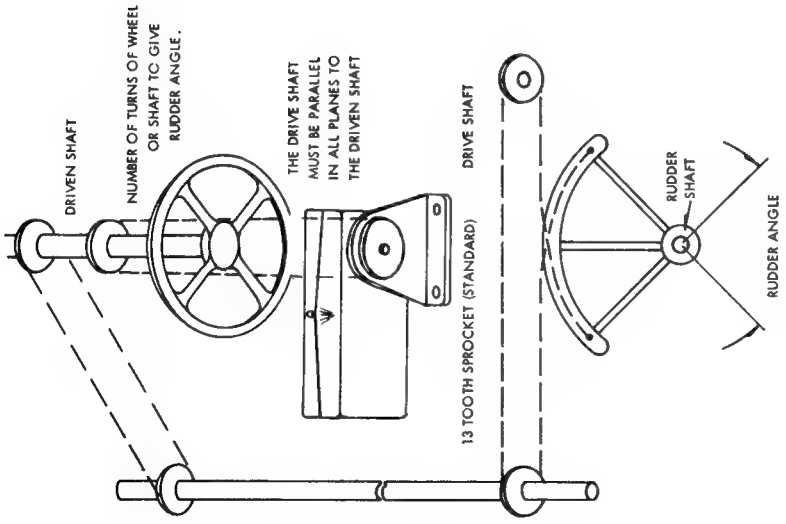
The clutch cable is pushed through the rubber grommet and fixing clamp and the inner cable fed through the fixing block until approximately 1/8 inch protrudes ensuring that the clutch knob is pushed fully home. The fixing block grub screws and fixing clamp screws can now be tightened.

Check the clutch operation before replacing lid.

MD2

The outer cable is held by the fixing clamp and the inner fitted to the sprung lever so that the end faces away from the case. This is accomplished by pulling the lever off the spindle before fitting the cable. With the knob pushed fully home, the outer cable can be clamped tight with the spring lever fully anti-clockwise.


SDU 2
MD 2
6 5/8
5·25 CRS
9 1/4
SDU 1
MD 1
6 1/8
4 5/8
5/8
3 CRS
10
1 3/8
2 HOLES 1/2 DIA
3/4
6 3/4
10 1/2


DRIVEN SHAFT
NUMBER OF TURNS OF WHEEL OR SHAFT TO GIVE RUDDER ANGLE.
THE DRIVE SHAFT MUST BE PARALLEL IN ALL PLANES TO THE DRIVEN SHAFT
DRIVE SHAFT
13 TOOTH SPROCKET (STANDARD)
RUDDER SHAFT
RUDDER ANGLE

Rack Drive

The Rack Drive is to be used for installations where it is impossible or impracticable to chain and sprocket the Drive Units to a rotating shaft. Fortunately, the Drive Units are grease lubricated and can therefore be mounted at any angle. You will see from the illustration below how the rack and pinion assembly is secured to the output shaft of the SDU1 and SDU2 If the gearbox is fitted on its side, that is to say the rack pinion axis is vertical or parallel to the rudder post, when the motor drives the rack in either direction it can push and pull a tiller bar which is attached to the rudder post. The arc that the tiller bar will describe because it is revolving on a radius about the rudder post is accommodated because the whole of the rack casing swivels around the output shaft of the motor. The rack is supplied with a threaded hole at either end. A suitable threaded rod must be made up to screw into the rack, secured with a lock nut and at the other end have a clevis or eye to accept a pin which is attached to either the tiller arm or the existing quadrant. The rack is threaded internally at one end $\frac{1}{2}$ whit (12TP1) and the other 12 mm 1.75 pitch.

The rack assembly is not supplied with the Drive Unit but its attachment to the Drive Unit is extremely simple. If the Drive Unit has a sprocket supplied, this must be removed.

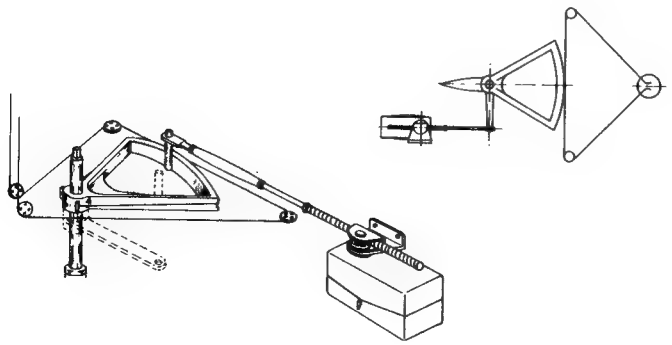
The rack is laid in the rack housing, the drive wheel is placed in mesh with the rack inside the rack housing, the shaft key is inserted into the drive wheel and the three parts are now slid on to the output shaft of the drive unit.

The collar is then placed on to the output drive shaft and secured with the two socket screws provided. In the case of the SD2/MD2 Unit, an extra spacer collar is provided. This is placed on the output shaft first and then the same procedure followed as for the SD1/MD1.

The feedback and limit switches are built into the Drive Units. To operate the SD1/MD1 limit switches, the rack must travel a total of 18 inches (458 mm) and the SD2/MD2 22.5 inches (572 mm). The output shaft of the motor may be rotated after the limit switch has operated to the maximum of the rack length, thus the limit switches can be made to operate before the rudder stops are reached.

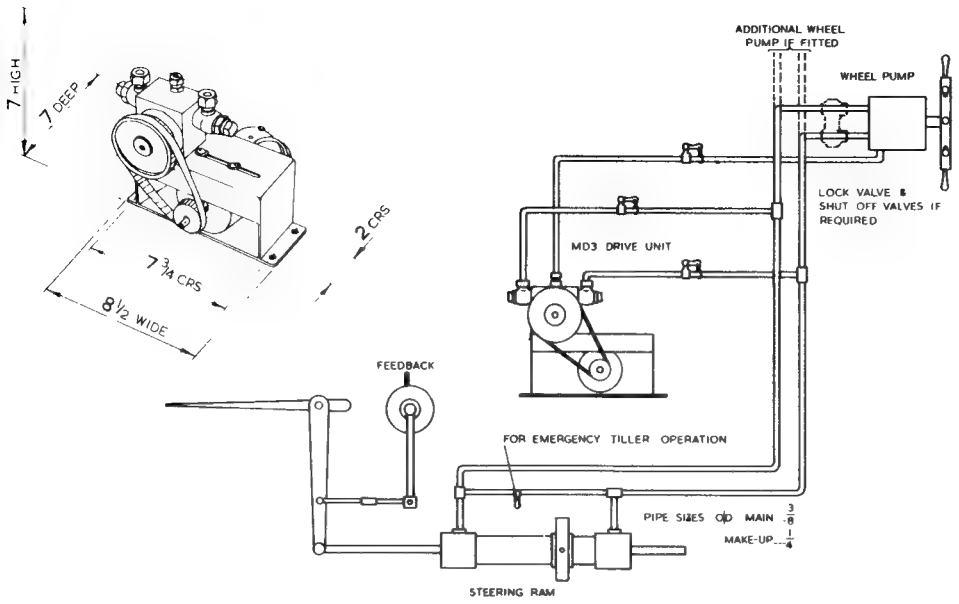
Centring Procedure

The centring procedure as explained on page 15 must be carried out before the rack is fitted to the output shaft. Once the Drive Unit is centred the rack assembly, with the rack in the centre position, can be assembled to the output shaft. Alternatively, the rack housing may be attached to the output shaft and the rack screwed into its housing until it is in the centre position.



MD3 INSTALLATION

The MD3 Hydraulic Steering Unit is designed to power hydraulic steering systems that have a total cubic inch oil displacement of not more than 18 cubic inches in the rudder cylinder or ram when it moves the rudder from full left to full right. It is piped into the steering system as in the following diagram:



It is essential that the steering gear is fitted with a non-return valve, as would be used in two steering position installations, to prevent the steering wheel 'motoring' when the pump of the hydraulic Pilot operates. It is also essential that the make-up pipe is installed. This relieves the pressure on the pump seal and must connect into the bottom of the steering wheel pump or, if a tank is fitted, this pipe must be led into the tank

When equipment is despatched from the factory, it has the 52 cubic inch per minute belt fitted. There are two other pulleys supplied with the pump and they give the oil flows shown below. The pump itself is always fitted with a 48 tooth wheel, the part No. is X24305 and the belt is part No. X24301.

Part No.	No. of Teeth	Ratio	Cubic inches per Minute	P.S.I.
X24304	24	1:2	70	350
X24303	18	1:2.7	52	350
X24302	12	1:4	35	350

The Unit must be securely mounted in a dry and well ventilated position. There are no restrictions as to the way the Unit is mounted, except that it must be below the wheel pump or tank of the vessel's steering system. The minimum diameter pipe sizes are main 3/8, make-up 1/4 for a maximum run of 12 feet, larger bore pipes must be installed for longer runs. It is good practice to instal between the pump and ram unit shut-off cocks as shown in the diagram opposite, enabling the Steering Unit to be removed for service without interference with manual steering.

How to select the correct pump tooth belt ratio for a known steering ram displacement is as follows. Example: a hydraulic ram with 10 or 12 cubic inch displacement, multiply by four (15 seconds for full left to full right rudder), which equals 40 cubic inches per minute. From the table opposite, select the 12 tooth X24302. In the case of the 12 cubic inch it would require 12 x 4 = 48 cubic inches per minute, select 18 tooth X24303.

Hydraulic steering systems having a steering ram of greater than 18 cu.ins. capacity can be operated by the MD3 with either reduced speed or movement. Many fast craft steer well with only little helm applied at normal cruising speed, but reduced speed requires full helm applied rapidly to keep them under control. This must be considered when deciding on the suitability of the MD3.

The speed at which the helm is applied is determined by the pressure (p.s.i.) which must not exceed 350 p.s.i.

It must also be remembered that if the Mate Proportional Remote Control (MPR) is to be used for power steering then it will be subject to the same Rudder Angle and speed limitations as the Auto Pilot.

Example: Vessel has 24 cubic inch steering ram to give 80 degrees of rudder. 20 degrees of rudder each side will steer automatically, therefore the oil required is 12 cubic inches in 15 seconds, 48 per minute. Note: it must be checked that the pressure does not exceed 350 p.s.i.

MF INSTALLATION

The RUDDER FEEDBACK UNIT is a small FEEDBACK UNIT that has no adjustable Limit Switches. Adjustment takes place by allowing the nylon moulded feedback arm to be deflected after it has operated the Limit Switches. The nylon is strong enough to withstand continual deflection of 20 degrees beyond the limit stops, which are 80 degrees. The FEEDBACK must, therefore, be mounted with suitable linkage, making a parallelogram to some part of the rudder mechanism, ensuring that before the rudder stops are reached, the nylon arm of the RUDDER FEEDBACK UNIT will have touched the mechanical stops on the cover of the RUDDER FEEDBACK UNIT, which will ensure that the drive is switched off before the rudder reaches its limit stops, preventing damage to the STEERING UNIT or the vessel's steering mechanism.

The Unit must be mounted to some part of the rudder linkage to accurately translate the rudder movement (see diagram opposite page), but not necessarily in the same ratio. Just as with a mechanical installation (see page 11), the automatic steering need not give full rudder and the Feedback can be mounted in such a manner as to achieve this, by means of the Sliding Bracket Assembly Part Numbers 1-B72031 Base, 1-B720311 Sub Plate, 2-X20250 Screw and 2-X24318 Plain Washer.

If the rudder turns 80 degrees to give full right to full left and the Feedback is mounted as shown in the diagram, the Feedback arm will move 80 degrees also. If the Feedback is mounted nearer to the Steering Ram, the linkage being maintained as a parallelogram, the ratio will be altered, the rudder moving less than 80 degrees. The limitation to the adjustment is the 20 degree deflection of the Feedback Arm; in the case of 80 degree rudder the limit switches can be set to operate at less 20 degrees each side, 40 degrees.

Should the Feedback Unit be mounted inverted to ensure the correct sense, the following M.F. wires in the MJ should be reversed: Black with Yellow and Green with White.

REMOTE STATION CONTROL

The REMOTE STATION CONTROL is complete with 20 ft. of six core screened cable, one end connected into the Unit, the other terminates into the REMOTE STATION RELAY BOX shown on page 7, the cable identifying colours are on each termination. There are no restrictions to cable length, therefore extra can be used if required. Special attention must be paid to screening, see that it is secured to the earthing screw, as shown in the drawing.

The most convenient location of the RELAY BOX is determined by the routing of the BINNACLE and SEAPILOT CONTROL cable, this has to be cut, cable insulation stripped back and connected colour to colour as shown on page 7. NOTE: the cable from the BINNACLE must go to the extreme right and the cable to the CONTROL from the adjoining group to the left.

The RELAY BOX is splashproof; however, it should be mounted below deck by means of two screws or bolts.

The Power cable is routed through the RELAY BOX, again see that it is done as shown, i.e. power is in the left hand gland and terminations and power out to the CONTROL is from the right hand terminations and gland. NOTE: the power and electronic cables are only identified by the thick and thin cables: the BROWN is positive and the BLUE negative. An explanation of the reason for the two supplies is given on page 12.

The REMOTE STATION CONTROL is splashproof and water tight when panel mounted. The design is such that it should always be mounted by the panel method, using the single U clamp to secure it. If it is not possible to panel mount, a box should be made, secured to the bulkhead and then the REMOTE STATION CONTROL should be panel mounted in the box.

No gasket or sealing compound is supplied. A suitable non-hardening compound to blend in with the colour of the panel to which the unit is to be mounted, should be used.

The HAND REMOTE CONTROL must plug into the CONTROL UNIT, however it is suitable to use for manual steering from a flying bridge. To do so, the best arrangement is to make up an extension cable, not retractile coil type, using plug part No. X 24338 and socket part no. X 24337. The socket would be panel mounted on the flying bridge and the standard HAND REMOTE would plug into it. To finish the installation, the REMOTE SOCKET Blank Part No. X730138 should be supplied to make the socket splashproof when the HAND REMOTE is not in use. Any 4 core 2 amp screened P.V.C. covered cable will be suitable.

NOTE: With HAND REMOTE switched to MAN. and the CONTROL UNIT switched to STANDBY, both the Port and Starboard lamp will be lit.

PRE-SAILING CHECKS

To be carried out with vessel alongside, moored, or at anchor.

1. ELECTRICAL SUPPLY, electronic and power, must be on.

2. HAND REMOTE CONTROL must be OFF or not fitted.

3. STANDBY/DUTY, check Switch is to STANDBY.

4. YAW, set to 3.

5. TRIM, set to vertical (zero).

6. RUDDER, set to 3.

7. Wait until the INDICATOR LIGHTS are in balance (both out).

8. Check that it is safe to move the rudder.

9. Turn steering wheel to put vessel's rudder to centre.

10. STANDBY/DUTY, switch from STANDBY to DUTY.

11. TRIM. Turn to left (anti-clockwise) and the vessel's rudder must move to turn the vessel to the left. Repeat to the right. Return TRIM to centre.

12. LEFT/RIGHT SWITCH. Switch to the left and the rudder will move to turn the vessel to the left in a series of small steps.

    NOTE: 12 can only be checked with the vessel's head steady (not swinging to the tide or wind). The reason for the small steps is that the rudder moves faster than the BINNACLE and waits for the BINNACLE to catch up.

13. HAND REMOTE CONTROL. Fit to socket and switch to MAN. With the Control Knob centre, the rudder will be centre. Turn to LEFT AND RIGHT and the rudder will follow proportionately. Switch back to AUTO.

14. REMOTE STATION CONTROL (if fitted), INDICATOR LIGHT will be ON, deflect OFF/ON Switch to OFF and hold until light goes OFF. Check that manual steering is working. Switch to ON and light is ON immediately, check LEFT/RIGHT Switch as at 12.

    TEST COMPLETE

OPERATING INSTRUCTIONS

We hope our illustrations will be self-explanatory.

RUDDER This is the vital control. It adjusts the amount of rudder required to steer the craft at all times. Example: Dead flat calm sea, under power. To steer the craft within one degree, the rudder must be moved only 1/5 of a degree. Example: The same craft under sail, borad reaching, may well require 5 degrees.

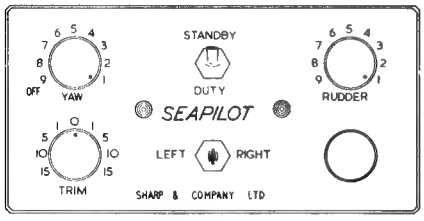
This is what the Control does, infinitely varies the amount of rudder in respect of a known Compass or Wind Vane error.

TRIM Applies 'weather helm', required when conditions are such that vessel does not steer a straight course with the helm amidships.

YAW De-sensitises the Electronic Circuitry to give a Dead-band to allow the craft to yaw naturally without rudder movement. Correct adjustment means less rudder movements per minute and consequent power (battery) requirements. The YAW control should be increased in rough conditions to allow the vessel to YAW naturally so as to conserve battery power.

Initial setting of controls requires time to allow the vessel to settle down after each setting change. Remember approximate settings to speed future adjustment.

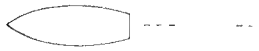
1. Switch to STANDBY and Set Controls as shown.



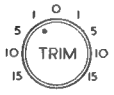
2. Steer vessel to desired course and switch to Duty when course lamps are balanced, i.e. both out. (This may take up to 20 seconds)
Auto Pilot now in control.

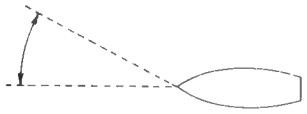
3 Increase RUDDER control until vessel oversteers (too much helm applied).

4 Decrease RUDDER control until vessel steers straight course.



5 Adjust TRIM to correct error.

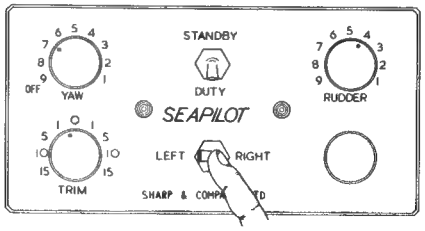


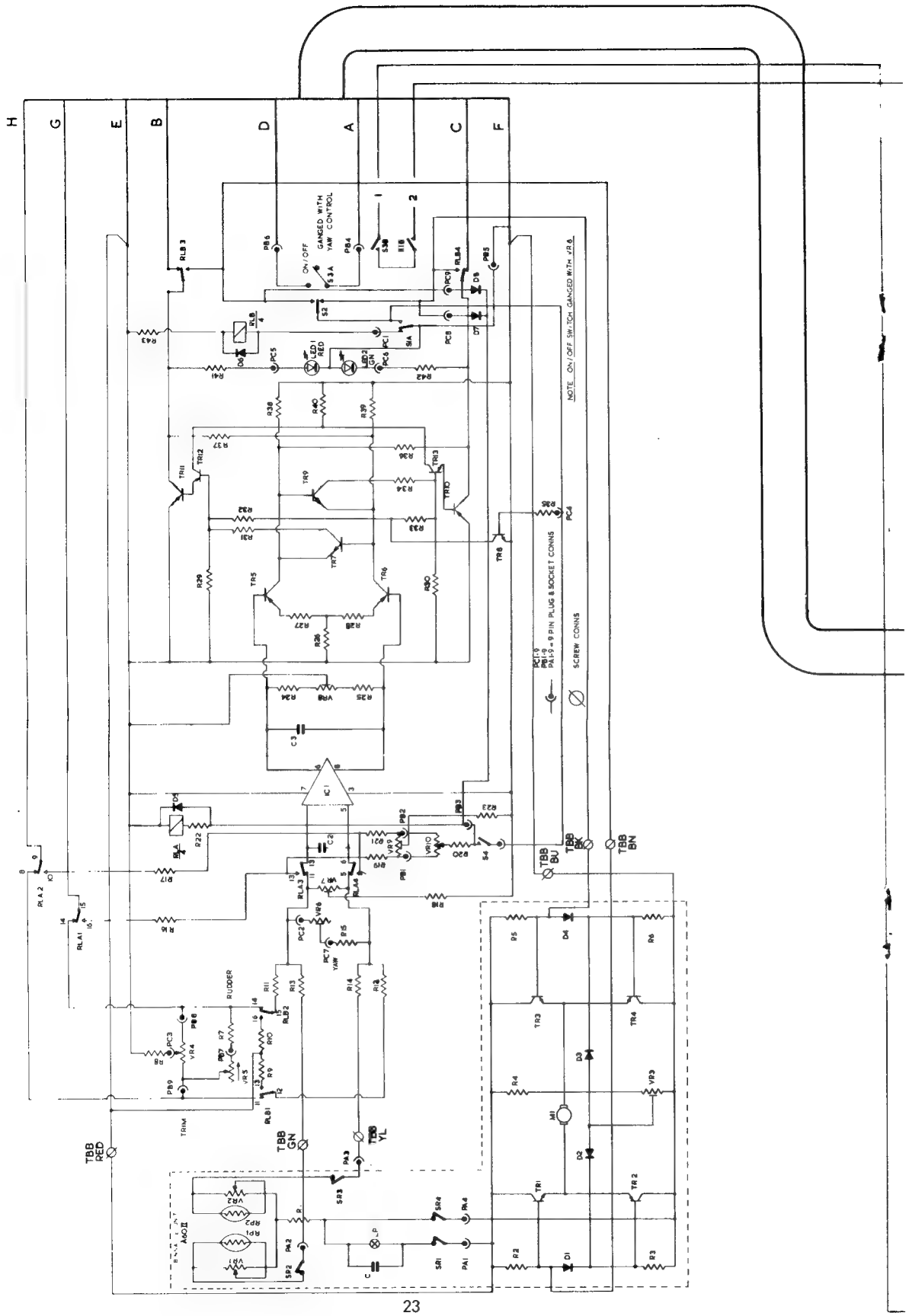


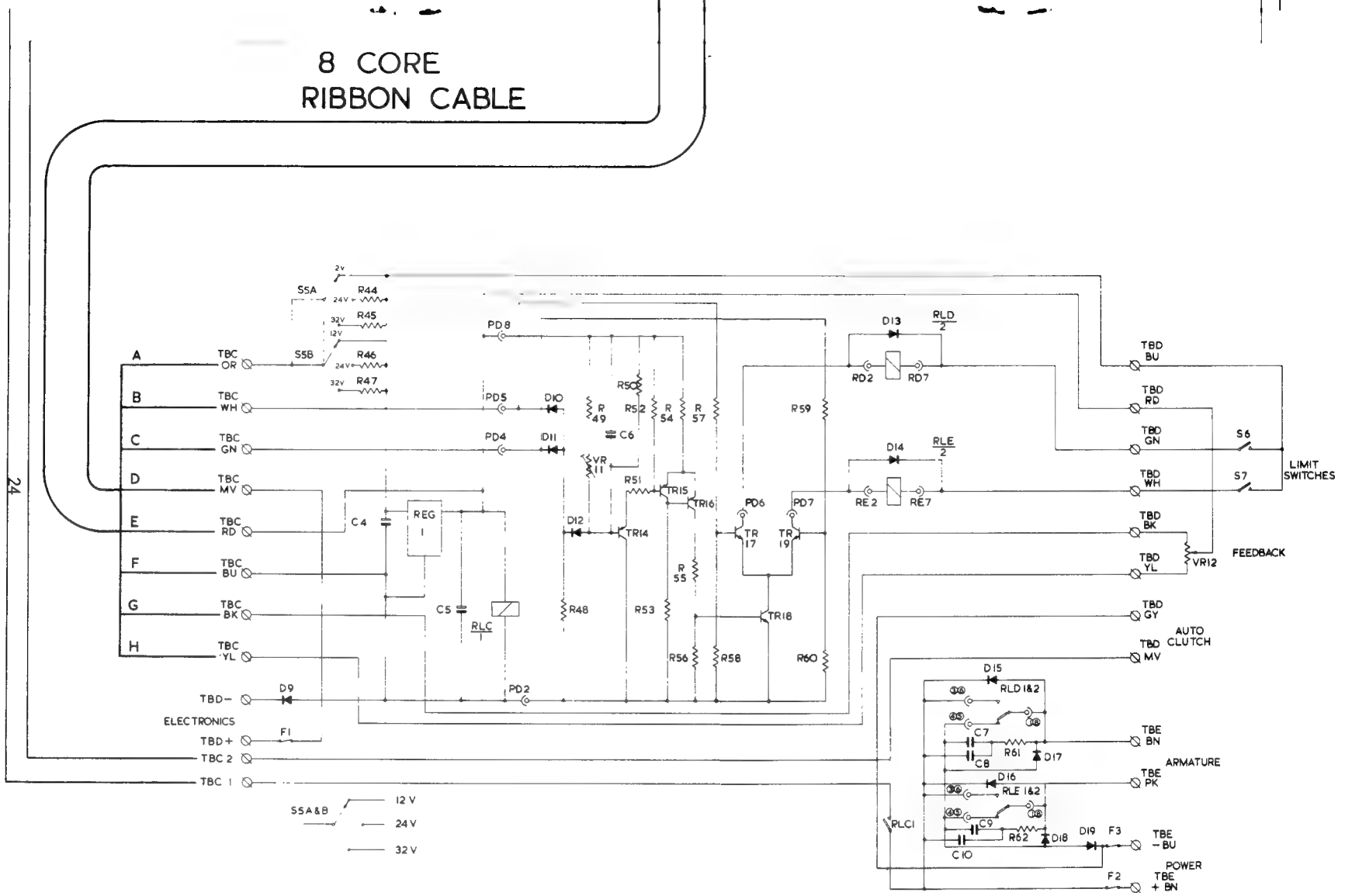
6 Adjust YAW to suit conditions.

Increase to de-sensitise Pilot.

7. To make course changes while steering automatically depress the Left/Right switch as desired releasing just before required heading is reached, to allow for overshoot.




H
G
E
B
D
A
C
F
ON / OFF
GANGED WITH YAW CONTROL
S3A
S3B
S1B
1
2
RLB3
RLB4
RLB1
RLB2
RLA1
RLA2
RLA3
RLA4
LED1 RED
LED2 GN
D5
D6
D7
D8
NOTE ON / OFF SWITCH GANGED WITH VR6
PC1 PC2 PC3 PC4 PC5 PC6 PC7 PC8 PC9
PA1-9 = 9 PIN PLUG & SOCKET CONNS
SCREW CONNS
TR1
TR2
TR3
TR4
TR5
TR6
TR7
TR8
TR9
TR10
TR11
TR12
IC1
VR1
VR2
VR3
VR4
VR5
VR6
VR7
VR8
VR9
VR10
RUDDER
TRIM
YAW
TBB RED
TBB GN
TBB YL
TBB BU
TBB BK
TBB BN
M1
LP
SP1
SP2
SP3
SP4
SR1
SR2
SR3
SR4
AMOII


8 CORE
RIBBON CABLE
24
A
B
C
D
E
F
G
H
TBC OR
TBC WH
TBC GN
TBC MV
TBC RD
TBC BU
TBC BK
TBC YL
TBD–
TBD+
TBC 2
TBC 1
ELECTRONICS
SSA&B
12 V
24 V
32 V
SSA
SSB
R44
R45
R46
R47
PD8
PD5
PD4
D10
D11
D12
D9
F1
C4
C5
C6
REG 1
RLC
VR 11
R51
TR15
TR16
TR14
PD6
PD7
TR 17
TR 19
TR18
R48
R49
R50
R52
R54
R57
R59
R53
R55
R56
R58
R60
D13
RLD 2
RD2
RD7
D14
RLE 2
RE2
RE7
TBD BU
TBD RD
TBD GN
TBD WH
TBD BK
TBD YL
TBD GY
TBD MV
S6
S7
LIMIT SWITCHES
VR12
FEEDBACK
AUTO CLUTCH
D15
RLD 1&2
C7
C8
R61
D17
TBE BN
ARMATURE
D16
RLE 1&2
TBE PK
C9
C10
R62
D18
D19
F3
TBE – BU
F2
POWER
TBE + BN
RLC1

SEAPILOT CONTROL UNIT AND BINNACLE CIRCUIT DESCRIPTION
SUPPLY VOLTAGE CIRCUIT AND STABILISER

The positive line of the electronics supply is connected via fuse F1 and the Mauve terminal to switch S3A which is ganged with the Yaw control. With the switch closed, the supply runs to the Orange terminal and through S5A2B, the voltage selector, via R46 or R47 to Reg 1 which provides a stabilised voltage of nominally 8 volts. The negative line is connected to the circuit via D9 which provides polarity protection. Capacitors C4 and C5 are included to suppress spurious transient voltages.

BINNACLE UNIT

The stabilised voltage from the Control Unit is connected via the red and blue terminals of upper printed circuit board to the Binnacle circuit.

Two photo-resistors RP1 and RP2 are illiminated by LP1 via a magnetised polaroid compass card and fixed polaroid segments positioned above the photo-resistors. With the bowl aligned with magnetic North, equal light will fall upon the RP1 and RP2.

Any misalignment of the bowl will cause more light to fall on one photo-resistor than on the other. VR1 and VR2 are connected across RP1 and RP2 to balance the output which is connected to the Control Unit via Yellow and Green terminals.

The automatic course sensing is achieved by a small precision motor mounted in the lower half of the Binnacle rotating the compass sensing bowl via a gear train. The motor is mounted within a magnetic shield which virtually eliminates all magnetic effects of the motor on the compass bowl. The sensing bowl electronics are connected to the terminal block via slip rings SR1-4.

The Binnacle motor is controlled by the circuit comprising TR1-TR4 found on the motor printed circuit board and its function is as follows:

The motor control terminals, Black and Brown, are connected via relay contacts RLB3 and RLB4 to either output transistors TR11 and TR10, on Standby, or Left/Right switch S2, on Duty. In the self-seek mode on Standby, the Control Unit senses when the output from the Binnacle bowl is balanced, i.e. when aligned with North. Any misalignment results in either TR11 or TR10 turning on thus taking the junction of either

R2 and D1 or R5 and D4 positive and hence either the junction of TR1 and TR2 or TR3 and TR4 will go positive. The other junction will remain at a potential determined by the resistor divider networks R2 and R3 or R5 and R6, therefore a voltage will appear across the motor armature. The polarity of this voltage will be such that the motor drives the compass bowl into balance.

With the Control Unit switched to Duty, the motor control terminals are connected to the Left/Right switch. When this is depressed either the base of T1 or T2 is taken negative and diode D1 or D4 is reversed biased so that the potential on the base of TR2 or TR4 is determined by the setting of VR3. This results in the voltage across the motor armature being dependent on VR3 setting.

CONTROL UNIT

The upper printed circuit board contains all the signal sensing and control function electronics. The output from the Binnacle Sensing Unit is connected to the circuit via the Yellow and Green terminals which are connected to resistors R13 and R14 to form a bridge circuit with the feedback potentiometer VR12 via resistors R11 and R13.

An unbalanced signal from the Binnacle produces a voltage at the input of amplifier IC1 which through the subsequent circuitry causes one of the drive relays to operate rotating the Drive Unit and hence the feedback potentiometer until the bridge reaches a new balance. Obviously the greater the unbalanced signal from the Binnacle, the further the feedback potentiometer will be required to rotate to rebalance the bridge circuit. The RUDDER control VR5, is connected across the feedback potentiometer and hence reduces the effect of the feedback thus requiring it to move further, i.e. more rudder applied, to balance the bridge circuit, varying the resistance of the Rudder control, will therefore vary the amount of rudder applied to correct a given course error. The TRIM Control VR4, the slider of which is connected via R8 to the positive line, is also connected across the feedback potentiometer and will bias the bridge circuit so that the feedback potentiometer and hence the rudder will move to a new position to rebalance the circuit.

The Yaw control, VR6, connected across the input of amplifier IC1 shunts the resultant signal from the bridge circuit, therefore decreasing the effective sensitivity of the amplifier. Reducing the resistance of VR6 enables the vessel to deviate further from its set course before applying corrective rudder.

Preset VR7 balances the differences between the bridge resistors and the amplifier bias currents. Contacts RLB1 and RLB2 switch in fixed resistors in place of the Feedback circuit on Standby enabling the binnacle to self-balance. Contacts RLA1-4 switch out the Binnacle bridge circuit and controls connecting the Feedback potentiometer to another bridge circuit formed by R16, R17, R19, R20 and the Hand Remote potentiometer VR10. Relay RLA is energised by the Hand Remote switch S4 when set to Hand. Preset VR9 balances out any differences in the Hand Remote bridge circuit.

The output of IC1 is further amplified by a differencial amplifier formed by TR5 and TR6. Preset VR8 balances the input offset voltage of the amplifier circuit. The output of the amplifier is connected to two transistors TR7 and TR9 connected in opposition so that only one will turn on at a time depending on the polarity of the output voltage. With the output less than the threshold voltage of TR7 and TR9 (i.e. approx. 0.6 volts), both transistors will remain off.

The collectors of these transistors are connected to the bases of Darlington configurations formed by TR11 and TR12 and TR10 and TR13. The collector of TR11 is connected via R37 to the collector of TR6 and the collector of TR10 is connected via R36 to the collector of TR5. These connections provide a small controlled amount of D.C. positive feedback to the output of the amplifier resulting in a cumulative switch action when either TR11 or TR10 turn on.

The collectors of output transistors TR11 and TR10 are connected to LED1 and LED2 which display the action of the circuit and particularly when the Binnacle has self-balanced on Standby.

The collectors are then connected via RLB3 and RLB4 to either the Binnacle drive circuit on Standby or to D10 and D11 via the White and Green terminals on the main printed circuit board.

Switch S4 of the Hand Remote is connected to the negative line via switch S1A so that RLA can only energise on the Duty mode. Transistor TR8 connected so that with the Hand Remote switch to Hand on Standby, both TR11 and TR10 and hence LED1 and LED2 are turned on to act as a warning that the Binnacle will not self-balance. Diodes D7 and D8 inhibit the action of the Left/Right switch when the vessel is being steered by Hand Remote.

The output from the collectors of TR11 and TR10 are connected to the cathodes of diodes of D10 and D11 and to the bases of TR17 and TR19 whose collectors are connected to the drive relays RLD and RLE. The emitters of TR17 and TR19 are connected to the collector of TR18 which is driven by the time delay circuit formed by TR14-TR16. When either TR11 or TR10 turns on the base of either TR17 or TR19 and the cathode of diode D12 via D10 or D11 is taken positive. This allows C6 to discharge slowly through VR11 and R49 until TR14 and TR15 turn off turning on TR16 and hence TR18. The emitters of TR17 and TR19 are thus taken to the negative line and can now conduct energising the appropriate drive relay. Diodes D13 and D14 are connected across the relay coils to suppress back emf.

When the circuit is balanced, TR11 and TR10 are both off and the time delay is reset by C6 charging rapidly through R48.

The drive relay coils are connected to the positive line via limit switches S6 and S7 which limit the amount of rudder applied. The common of these switches is connected via voltage selector switch S5A which selects the appropriate series resistor link, R42 or R43, to provide 12 volts across the relay coils.

The Auto clutch terminals are connected to the Drive supply via terminals 1 and 2, which are connected to the Standby/Duty switch S1B and On/Off switch S3B, and the contacts of RLC1. RLC is energised by the stabilised supply.

The Drive supply is protected by fuses F2 and F3 and polarity protected by D19. The Drive relay contacts are protected against motor sparking by diodes D15-18 and capacitors C7-C10.

MAINTENANCE GENERAL

Always pay special attention to the vessel's steering gear, see that it is well lubricated and works easily: the Automatic Pilot cannot tell you it has become too heavy, as your arms would. This includes the chain drive from the Drive Unit to your vessel's steering system.

FEEDBACK. This Unit is usually 'out of sight and out of mind'; inspect at regular intervals, oil and grease the linkage system and see that all fastenings are secure. Pay particular attention to loose gear that may be stowed nearby and could fall onto the linkage in a seaway.

The two large relays in the Control Unit should be inspected regularly. The period between inspection and cleaning must be determined by experience as the load they switch will vary significally from vessel to vessel, but suggest initial inspection should occur after approximately 50 hours of use.

FUSES

The electronic fuse should only fail because of a fault in the circuit or a loose connecting wire. It is advisable to call in a service engineer should the fault be for any but obvious reasons.

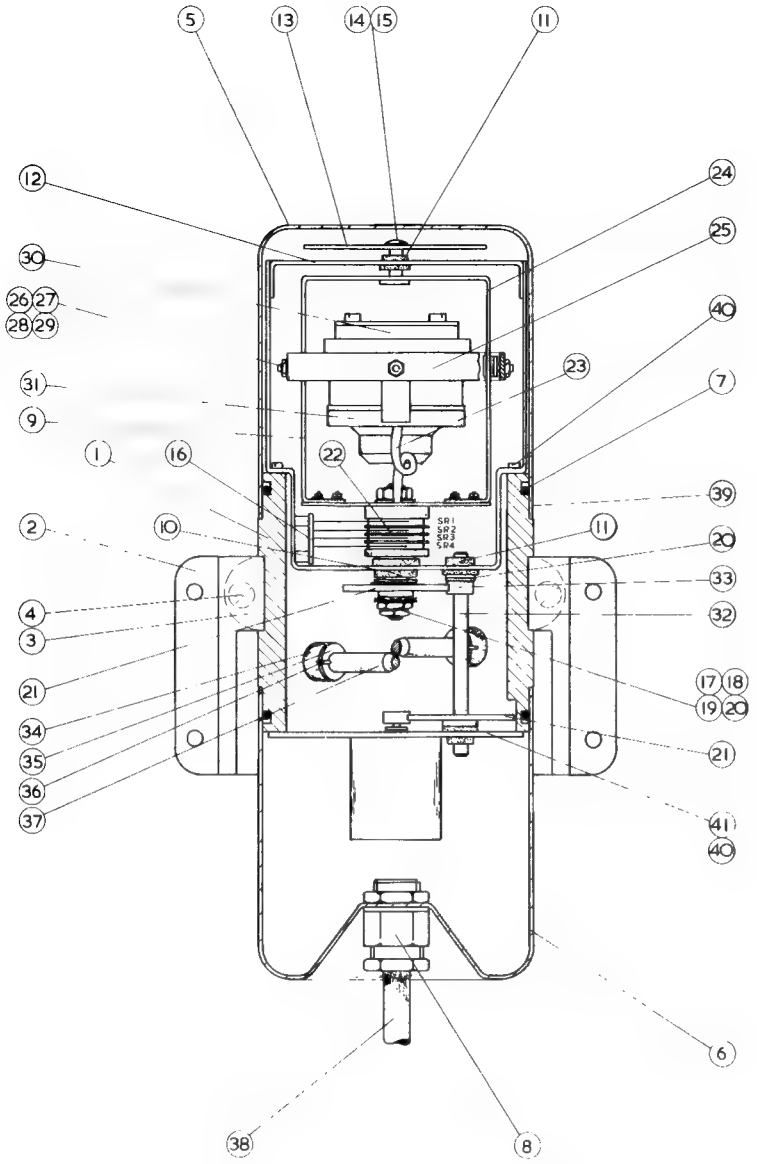
The power fuses are subject to constant surge loads when switching the motor and should be inspected at regular intervals that have been determined by experience. Too frequent power fuse failure usually indicates too much load, steering may have become stiff or motor brushes and commutator require service.

TROUBLE SHOOTING

TROUBLE	CHECK	ACTION
No indicator lights when YAW switched on.	Power supply.	Switch on.
	Power supply polarity.	Reverse polarity.
	Electronic Fuse.	Replace and check why fuse blown.
	Binnacle in Balance.	Turn TRIM Control.
	Bad terminal connection.	Check electronic and Binnacle terminations, see pages 5 to 7.
	Binnacle lamp blown. Check for open circuit at Control Unit, page 29.	Replace lamp.
ONE indicator light only.	Lamp (indicator).	Replace.
	Switch may be to DUTY.	Switch to STANDBY.
	Binnacle motor supply at terminal, page 29.	If supply O.K., fault is in Binnacle, follow through. If no supply, fault is in Control Unit, follow through.
	Read milli-volts at YL/GN on Control termination page 5 - 7	No reading indicates photo-resistor failure.
	Binnacle continually drives.	Slip ring open circuit, replace or repair.
	Binnacle hunts.	Open circuit in one place - repair.
No power from Drive Unit (Electric).	Power fuses.	Replace and check motor turns in both directions without blowing new fuse.
	All mechanical links and fixings, i.e. chain shaft keyway screws.	Repair as required.
	Clutch. Motor can be heard to run and shaft does not revolve.	Check supply at terminations, page 5 - 7 If O.K., Steering Unit will have to be dismantled to check for mechanical fault or circuit failure, see page 40.

TROUBLE SHOOTING

TROUBLE	CHECK	ACTION
No power from Drive Unit (Electric).	Power supply.	May be from fused distributor board or other supply than electronic.
	Relays in Control Unit contacts.	Clean if required, replace if required.
	Relays not pulling in.	Check through circuit, page 23 - 24
Intermittent Steering Unit failure.	Brush gear.	Repair or replace.
	Commutator.	Clean and cut back segments.
	Faulty Relay.	Check relays in Control Unit.
	Electronic failure (Relay does not pull in).	Check circuit
Steering Unit (Hydraulic).	As for electric model in regard to motor and motor switching.	As required.
	Oil level too low, look for leaks.	Top up, repair.
	Pump Belt Drive.	Adjust or replace.
	Pump pulleys loose on shafts.	Tighten securing screws.
	Automatic non-return valve seal, see page 41, Part No. 35, 'O' Ring.	Replace.
	Pump with oil flow blocked, motor draws 20 amps with 12 volt supply.	If test less amps, pump replacement required. Block flow by removing Feedback arm so limit switches inoperative and drive steering hardover, page 12. Use stop valves if fitted.
Manual Steering appears to slip.	Automatic non-return valve in Pump Unit, page 41. Look for dirt on ball seatings.	Clean as required. Whole of steering system may have to be flushed out and filled with clean oil.
Understeer and/or Oversteer.	Check RUDDER and YAW Controls for position.	Read page 22 carefully.
	Binnacle being upset magnetically.	Look for portable radio, metal tins, camera, light meter, etc.
	Heeling error.	Check page 11
Rudder movement unequal.	Centering procedure, page 15 (electric), page 18 (hydraulic).	Correct if required.
	Potentiometer drive out of position, see page 58, Feedback plate assembly.	The driving balls may not be locating hard enough in the holes in the gear wheel, adjust springs. The potentiometer arm not wedging into limit switches, adjust as required.
	Feedback Unit linkage out of correct alignment.	Adjust as required.
	Faulty Feedback potentiometer.	Measure at terminations in Control Unit page 6 or 7 Yellow/Black.
	Hand Remote Potentiometer.	Not correctly aligned, adjust.
	Binnacle photo-resistors out of balance. Measure + lead meter at Green - lead meter at Yellow ON Course 0v. 30° Clockwise +60mV ± 10 30° Anti-clock -60mV ± 10.	Any other reading, return to Factory.
Rudder moves one way only.	Limit Switches. Limit Switch connections.	Replace. Make good.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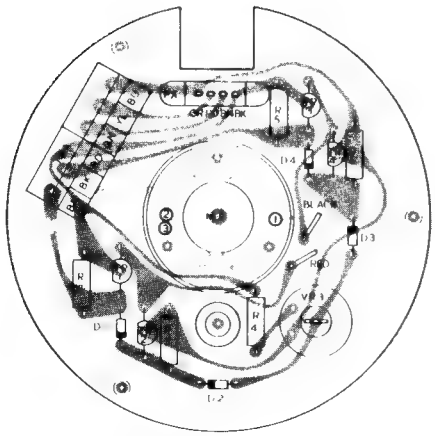
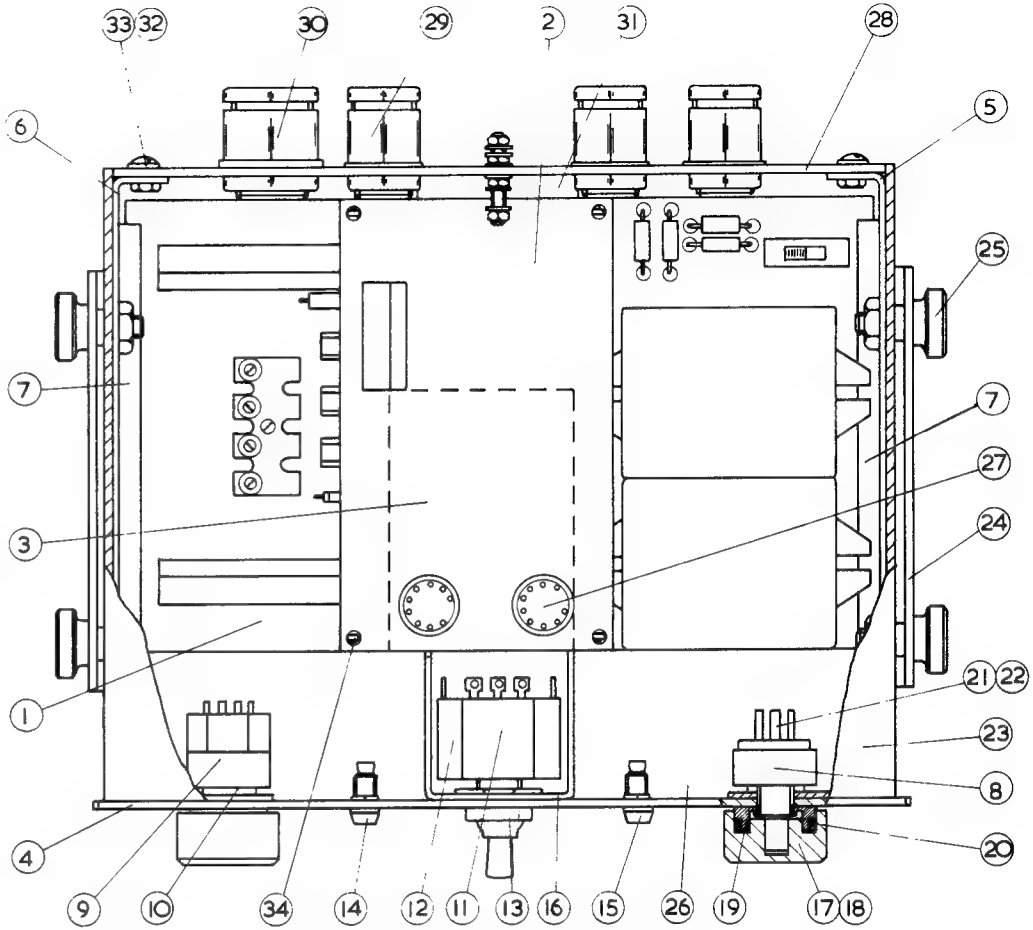


A6011 BINNACLE PARTS LIST

1	Housing	1	C 750913
2	Mounting Bracket	1	C 720627
3	Mounting Strap	1	C 720544
4	Screw $\frac{1}{4}$ Whit. 5/8 Lg. Ch.Hd. Nylon	2	X 24324
5	Top Cover	1	B 750938
6	Bottom Cover	1	B 750939
7	'O' Ring RM0845-30 P5	2	X 24493
8	Gland-Cable Type P16	1	X 24463
9	Housing Bracket	1	B 750915
10	Bearing FCM10	1	X 24492
11	Bearing FCM7	2	X 24491
12	Bridging Piece	1	B 750916
13	Scale Silk Screened	1	A 750940
14	Screw 6BA x 3/16 Rd.Hd. Brass	1	X 23485
15	Washer Shakeproof 6 BA Ph.Bronze	1	X 20186
16	Slip Ring Wiper PCB Assembly	1	A 750931
17	Spindle	1	A 750920
18	Nut 5 mm Lock Brass	2	X 24497
19	Washer Crinkle Berilium	2	X 24500
20	Washer Plain Brass	2	X 24501
21	Gear 70 tooth	2	A 750403
22	Bowl Support PCB Assy. with Slip Rings	1	B 750932
23	Cable Flexible	1	A 750703
24	Bowl Support Frame Sub Assy.	1	A 750926
25	Gimbal Ring	1	B 750918
26	Bearing Grub Screw 6 BA Brass	4	A 750706
27	Nut 6BA Lock Brass	4	X 23517
28	Anti-Vibration Disc Brass	2	A 750930
29	Anti-Vibration Disc Rubber	2	A 750929
30	Bowl Assembly	1	B 740301
31	Weight and Cable Clamp	1	B 750701
32	Shaft	1	A 750934
33	Secondary Drive Gear	1	A 750911
34	Corrector Sleeve	4	A 720242
35	Washer $\frac{1}{4}$ I/D x $\frac{1}{2}$ O/D	4	X 20371
36	Correction Magnet	4	A 711103
37	Corrector Rod	2	A 720513
38	Cable 6 way Screened	3.6m	X 24367
39	Screws 4BA Rd.Hd. Chrome	6	X23371
40	Screws 6BA x $\frac{1}{4}$ Ch.Hd. Brass	5	X20274
41	Printed Circuit Board Assy: Comprising:	1	B 750420
1	P.C.B. Bearing Assembly	1	A 750419
2	Terminal - 3 way	2	X 24460
3	Socket - A23 - 20705	1	X 24495
4	Magnetic Shield	1	A 741102
5	Collet Clamp	1	A 741103
6	Collet Clamp Ring	1	A 741104
7	Screw - 6BA x 1 Lg. Ch.Hd.	3	X 24457
8	Nut - 6BA Full	3	X 23467
9	Washer - 6BA S/Proof	3	X 20186
10	Drive Gear	1	A 750402
11	Transistor - 2N 3709	2	X 21937
12	Transistor - 2N 4062	2	X 22713
13	Min Preset - 1 K ohm	1	X 24458
14	Diode - IS920	4	X 22714
15	Resistor - 1 K ohm	2	X 21827
16	Resistor - 2.2 K ohm	2	X 21833
17	Resistor - 1.5 K ohm	1	X 22171
18	Motor - 050/0055	1	X 24455
19	Gearhead - 05/1485	1	X 24456

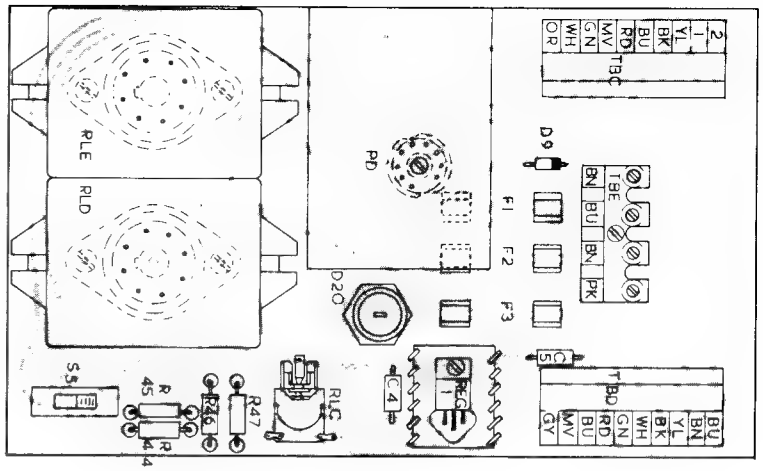
SCU CHASSIS PARTS LIST

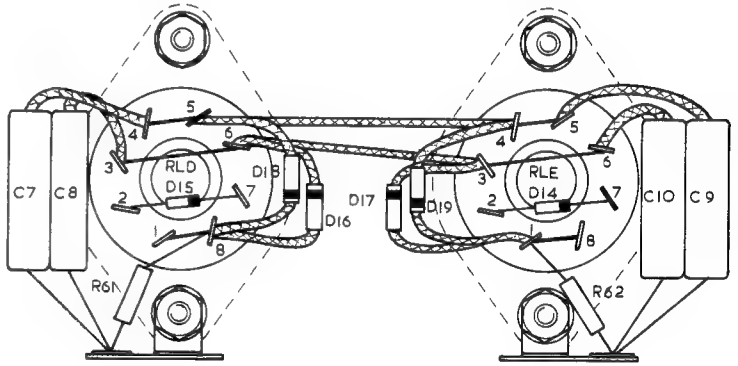
1		Printed Circuit Board Assembly	1	B 750109
2		Printed Circuit Board Assembly	1	B 750510
3		Printed Circuit Board Assembly	1	A 710904/4
4		Front Panel Silk Screened	1	B 750512
5		Bracket Right Hand	1	B 750408
6		Bracket Left Hand	1	B 750409
7		P.C.B. Holder	2	A 750422
8	VR5	Rudder Pot. 5 K ohm Log H45	1	X 24203
9	VR6/S3	Yaw Pot. 5 K ohm Log AY45	1	X 24202
10	VR4	Trim Pot.10 K ohm Lin 45 H	1	X 24195
11	S1	Switch D.P.C.O	1	X 24363
12	S2	Switch S.P.C.O. Centre OFF	1	X 24362
13		Rubber Sealing Boot	2	X 24361
14	LED1	Light Emitting Diode Red	1	X 24479
15	LED2	Light Emitting Diode Green	1	X 24480
16		Board Support Bracket	1	A 751103
17		Knob Control	3	A 721021
18		Screw - 4BA x 3/16 Socket Set	6	X 24242
19		Sealing Nut	3	A 721020
20		Seal 'O' Ring R2075-P45	3	X 22759
21		Socket SA 2368	1	X 24337
22		Socket Remote Blank	1	A 730138
23		Case	1	B 750410
24		Support Bracket	1	B 750411
25		Knob Knurled	4	A 721114
26		Loom	1	B 750604
27	PB-PC	Socket 9 way XLM9/UTS1	2	X 24213
28		Gland Plate Silk Screened	1	A 750513
29		Gland P16	3	X 24463
30		Gland P20	1	X 24464
31		Board Support	1	A 751104
32		Screw - 4 BA Mush.Hd. x 3/8	2	X 21658
33		Washer 4 BA Fibre	2	X 23491
34		Board Support Pillars	4	X 24481
35	(Not shown)	Console Mounting Brackets	2	A 750404

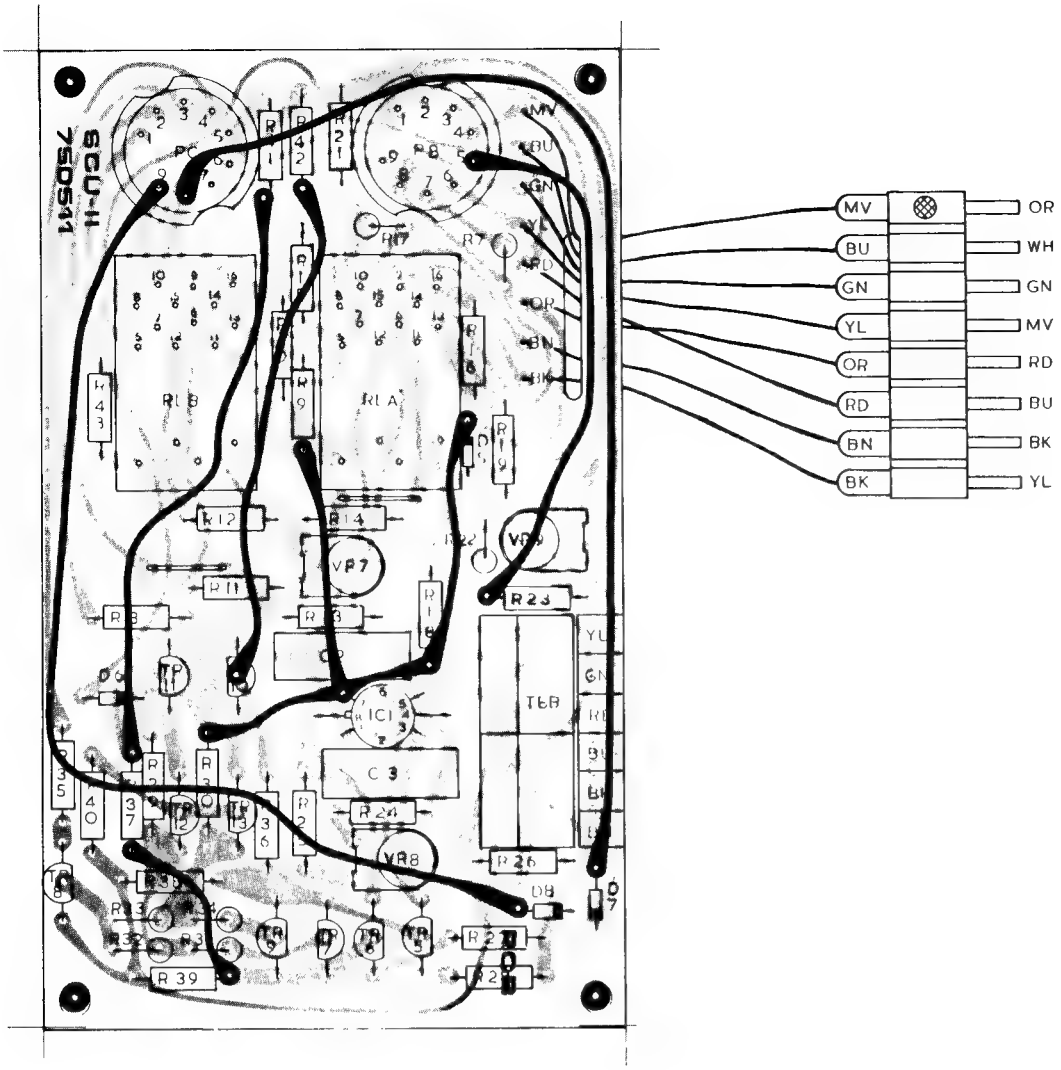


SCU11 MAIN PCB COMPONENTS

	Printed Circuit Board	A 750801
REG 1	Voltage Regulator 8 volt 7808 UC	X 24462
	Heatsink for REG 1 Modified TV21	A 750601
D9	Diode BYX36-150	X 23741
D13-D14	Diode IS920	X 22714
D15-D16	Diode 30S4	X 24454
D17-18	Diode BYX36-600	X 23743
D19	Diode 40HF40	X 24415
	Heat Sink for above	A 741203
R44	Resistor 33 ohm 5w	X 24485
R45	Resistor 51 ohm 5w	X 24484
R46	Resistor 82 ohm 3w	X 22761
R47	Resistor 150 ohm 5w	X 22891
R61-R62	Resistor 5.6 ohm ½watt 5%	X 21267
C4-C5	Capacitor 4 mf 40 volt	X 22571
C7-C10	Capacitor 1 mf 250 volt	X 22828
RLC	Relay Type 1051 6 volt	X 24450
RLD-RLE	Relay type MM2P 12 volt (for motor drive)	X21846
or	MJP2 (for spool drive)	
	Base Relay for above 2 off	X 21421
S5	Switch-Slide type P5 230 3 way	X 24467
F1	Fuse 1 amp $1\frac{1}{4} \times \frac{1}{4}$	X 22138
F2-F3	See Page 12	
	Fuse Holders for above 6 off	X 22412
PD	Socket 9 way XLM9/UTS1	X 24213
TBC-TBD	Terminal Block 10 way	X 24459
TBE	Terminal Block 4 way Colour Coded	X 20254
	TBB Colour Coding Strip	A 750602A
	TBC Colour Coding Strip	A 750602B
	TBD Colour Coding Strip	A 750602C
	Loom PCB	B 750117



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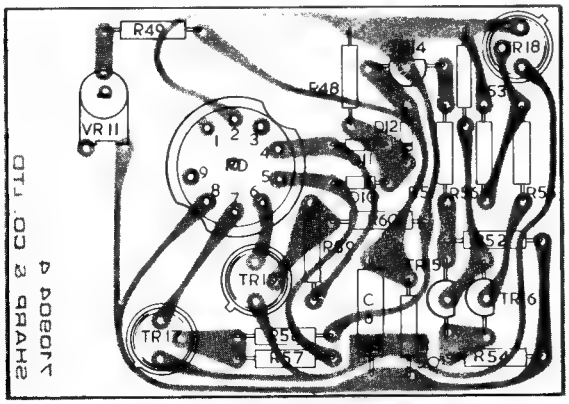


SCU SIGNAL PCB COMPONENTS

	Printed Circuit Board	B 750511
IC1	Integrated Circuit CA 3028B	X 24019
T5-6	Transistor 2N4062	X 22713
TR7-9	Transistor 2N 3709	X 21937
TR10-13	Transistor 2N 4062	X 22713
D5-D8	Diode IS 920	X 22714
R7	Resistor 27 ohm ½ watt 2%	X 22033
R8-10	Resistor 1 K ohm	X 21827
R11-12	Resistor 4.7 K ohm	X 22213
R13-14	Resistor 2.2 K ohm	X 21833
R15	Resistor 68 ohm	X 22020
R16-17	Resistor 27 K ohm	X 21834
R18	Resistor 47 K ohm	X 22056
R19 & 21	Resistor 10 K ohm	X 21831
R22	Resistor 33 ohm	X 22219
R23	Resistor 15 K ohm	X 21837
R24-25	Resistor 1.5 K ohm	X 22171
R26	Resistor 330 ohm	X 21930
R27-28	Resistor 27 ohm	X 22033
R29-30	Resistor 10 K ohm	X 21831
R31-34	Resistor 4.7 K ohm	X 22213
R35-37	Resistor 33 K ohm	X 21836
R38-39	Resistor 1 K ohm	X 21827
R40	Resistor 3.3 K ohm	X 22214
R41-42	Resistor 100 ohm	X 21835
R43	Resistor 47 ohm	X 21931
VR7	Preset Resistor 1 M ohm Min. Horiz	X 22609
VR8	Preset Resistor 220 ohm Min. Horiz	X 22616
VR9	Preset Resistor 22 K ohm Min. Horiz	X 22615
C2-C3	Capacitor 0.47 mfd 100 volt	X 24162
RLA-RLB	Relay 4 pole c/o	X 23906
PB-PC	Plug 9 way XLM/9/UTP1	X 24212
TBB	Terminal Block 2x 3 way	X 24460
	Ribbon Cable 8 way 6"	X 24487
	Fanning Strip 8 way	X 24461

SCU11 SECONDARY PCB COMPONENTS

	Printed Circuit Board	A 710904
TR14-16	Transistor 2N4062	X 22713
TR17-19	Transistor BFY50	X 23627
D10-12	Diode IS920	X 22714
R48	Resistor 680 ohm ½ watt 2%	X 21918
R49	Resistor 10 ohm ½ watt 2%	X 21831
R50	Resistor 220 K ohm ½ watt 2%	X 22510
R51-52	Resistor 4.7 K ohm ½ watt 2%	X 22213
R53	Resistor 10 K ohm ½ watt 2%	X 21831
R54	Resistor 100 ohm	X 21835
R55	Resistor 330 ohm	X 21930
R56	Resistor 150 ohm	X 21828
R57-60	Resistor 680 ohm	X 21918
VR11	Preset Resistor 100 K ohm	X 21243
C6	Capacitor 4 mfd 10 volt	X 22560
PD	Plug	X 24212

DISMANTLING A6011 (See Page 29)

The top and bottom covers are removed by undoing the three fixing screws of each and withdrawing from the centre housing over the 'O' ring seals (7). The cable gland (8) of the bottom cover must be loosened to withdraw it over the connecting cable. The cable can now be disconnected from the terminal block TBA. Plug PA can now be withdrawn noting which way round it is connected. The printed circuit board can now be removed from the centre housing (1). The lay gear spindle assembly (32) will now be free to be removed.

To remove the motor and gearhead from the printed circuit board assembly, the three screws holding the motor collet clamp and magnetic shield to the printed board must be undone and the assembly removed. Push out the motor collet assembly from the magnetic shield and then pull the two halves of the collet to release the motor gearhead. CAUTION: Great care should be taken to avoid knocking or any damage to the magnetic screen as this could destroy its screening properties with adverse effects on the Auto Pilots performance.

The bowl and gimbal frame assembly complete with slip ring assembly can now be withdrawn from the centre housing by releasing the two fixing screws.

Before dismantling further it is wise to observe and note how it is assembled as detailed drawings are not given in this handbook and to proceed strictly in the following order.

Remove the two screws that fix the slip ring collector printed circuit board to the main frame, noting which way round it is fitted. It can now be rotated around the slip rings so that it may be withdrawn. The gearwheel must now be removed by withdrawing the split pin. NOTE the order of plain and crinkle washers that form the slipping clutch. Remove the main frame bridging piece (12) by releasing four fixing screws. The gimbal frame and ring can now be withdrawn from the main frame.

The compass bowl and weight is removed from the gimbal ring by undoing the two pivot screws. CAUTION: The flexible cable between the slip ring PCB and bowl is delicate and great care should be taken to ensure that it is not stretched.

To remove the bowl from the weight, undo the six fixing screws but note that two wires from the festoon lamp are connected to the printed circuit board and also note that the photo-cells are positioned beneath the festoon lamp.

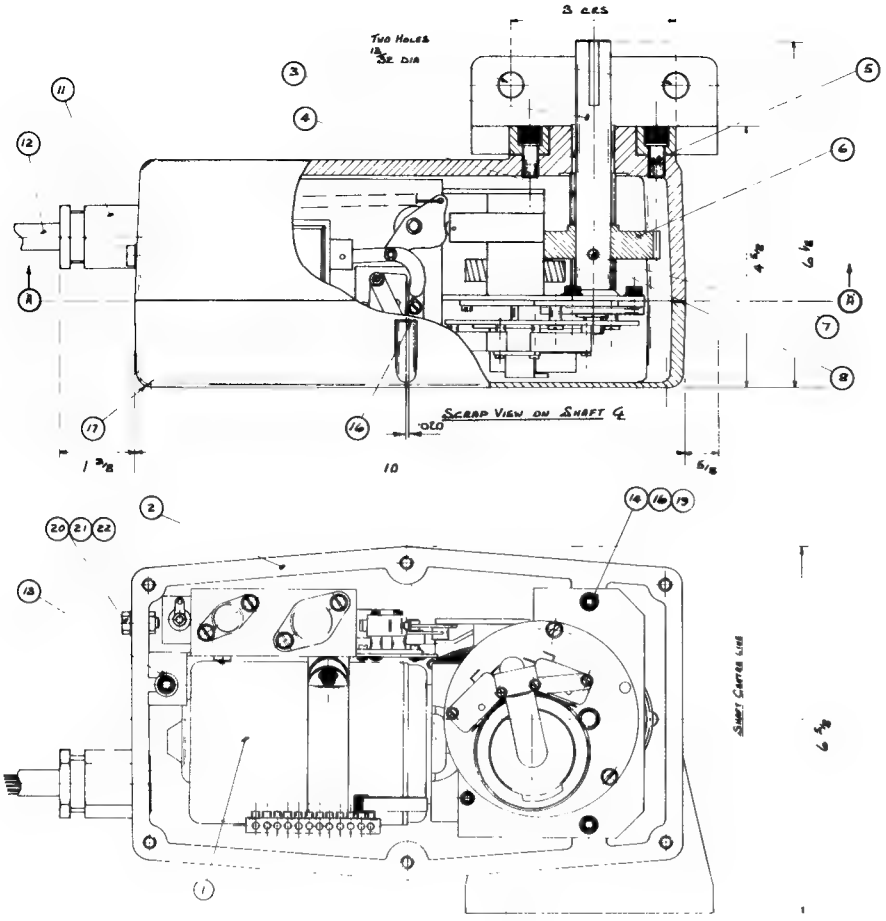
The festoon lamp can be removed by gently levering out the lamp contact clips from the slot and sliding them off the lamp contacts.

The compass bowl is filled with a special type of white spirit called Isopar G. Should it be necessary to fill the bowl, the bowl plug should be unscrewed with a suitable tool. Filling is best accomplished with a small syringe keeping the needle in the liquid so that no bubbles are introduced into the liquid. The bowl must be horizontal when filling and a bubble of approximately 10 mm. diameter left in the bubble dome next to the filler plug. Before replacing filler plug, fill filler hole with liquid so that no air is trapped when the plug is replaced.

Reassembly is carried out in reverse order to above taking account of the following points.

Ensure that the photocell printed circuit board is positioned with the photo cells beneath the festoon lamp. Ensure that the flexible cable has one twist in it before mounting in the gimbal ring. Adjust gimbal pivot screws so that the bowl is in the centre of the ring and there is a small amount of clearance to allow the bowl to gimbal freely. Ensure that locking nuts are tightened.

Tighten nuts on slipping clutch so that it slips when turned gently by hand (approximately 30 Newton c.m.). Ensure that the slip ring collectors are correctly positioned and on correct rings. Ensure that lay shaft is fitted before motor printed circuit board is fitted and insert plug PA in its socket the correct way round.



VIEW 'A-A' WITH LID REMOVED

1	Motor Assembly 12 volt	1	C721029	P.C.B.Assembly comprising	1	B730408	
	Motor Assembly 24 volt	1	C740108	P.C.B.Manufacture and Drilling	1	A730407	
2	Case Machined Assembly	1	A730127	Resistor 33 ohm ½ watt		X22919	R7
3	Output Shaft Assembly	1	A730128	Resistor 15 ohm 10watt		X24426	R8
4	Spacer Long	1	A730122	Tag Board 2 way Rt. Hd.	1	A710917	
5	Screw M6 x 16mm Long	4	X24372	Micro Switch Adjusting Plate	1	A740501	
6	Gear Output	1	A721012	Screw 6BA x ¼ Lg. Ch. Hd.	2	X20274/CP	
7	Pin Dowel 3/16 Dia. x 1 inch Long	1	X23066	Screw 6BA x 5/8 Lg. Ch. Hd.	2	X20019/CP	
8	Spacer Short	1	A730121	PCB Assembly comprising	1	A740405	
9	Lid Machined	1	C721206	PCB Manufacture & Drilling	1	A740404	
10	Bracket Machined	1	C721209	Resistor 680 ohm ½ watt		X21918	R1
11	Gland - 1 BSC Cat. No. 7X	1	X23344	Resistor 15 K ohm ½ watt		X21837	R2
12	Cable 11 core special 3.6 mtrs.		X24221	Resistor 22 K ohm ½ watt		X21929	R3
13	Washer Plain	1	X20032	Resistor 2.2 K ohm ½ watt		X21833	R4
14	Washer Shakeproof	3	X20110	Resistor 390 ohm ½ watt		X23895	R5
	Yoke Assembly, Sub Assembly comprising	1	B750508	Resistor 22 ohm ½ watt		X22022	R6
16	Screw M5 x 20mm Long	5	X24371	Transistor 2N3709		X21937	TR1, TR2
17	Screw M5 x 40mm Long	4	X24370	Diode IS920		X22714	D1, D2
	Solenoid Chassis Secondary Assy.comprising	1	C730207	Diode BYX36-150		X23741	D3, D5
19	Screwlock - Cat. No. 59	A/R	CT stock	Capacitor 220 mf 16 volt		X22559	C1
20	Screw ¼ BSF Hex.Hd. x ½ Lg.	1	X20069	Capacitor 15 mf 16 volt		X24425	C2
21	Washer - Fibre	1	X23499	Linkage Arm	1	A750503	
22	Nut. Hex..Lock ¼ BSF	1	X20197	Cam Assembly comprising	1	A750505	
	Gasket	1	A730412	Terminal Block 12 way	1	X24076	
	Feedback Plate Assembly	1	B710511				
	Spring - 7988645	1	X44355				

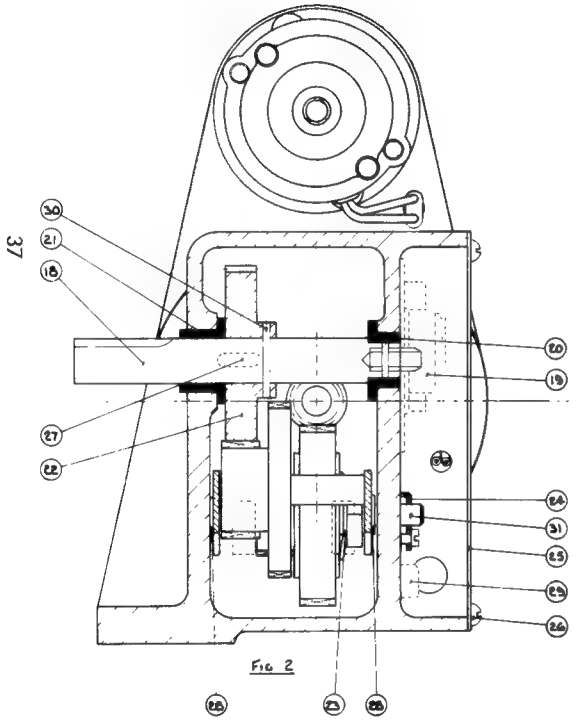


Fig 2

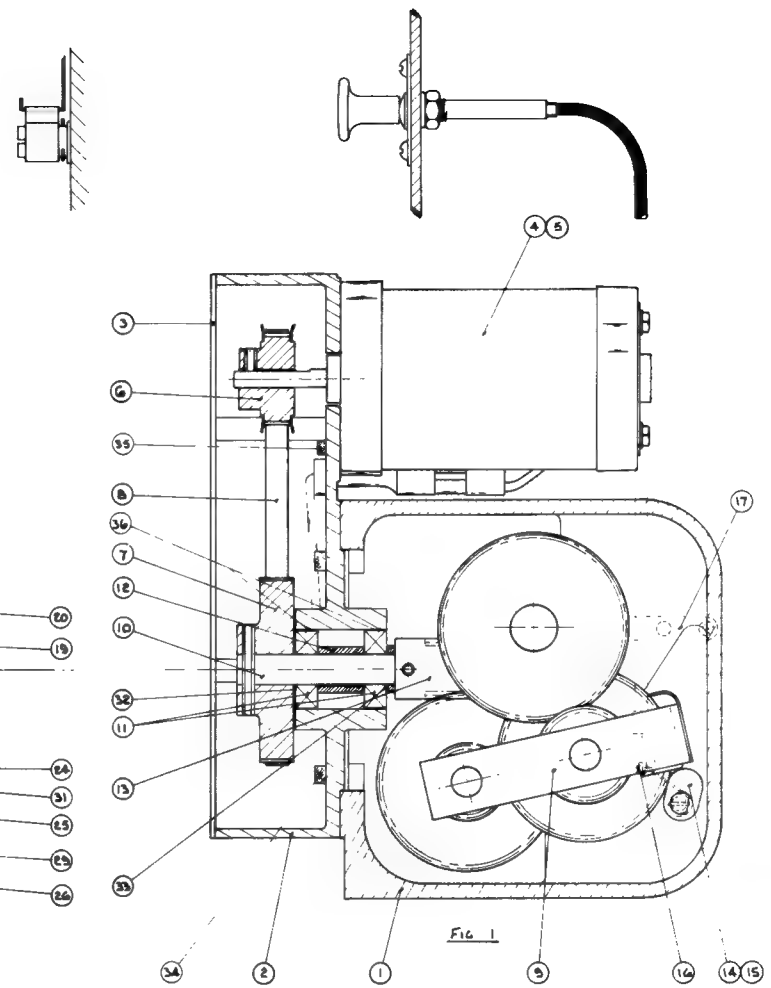
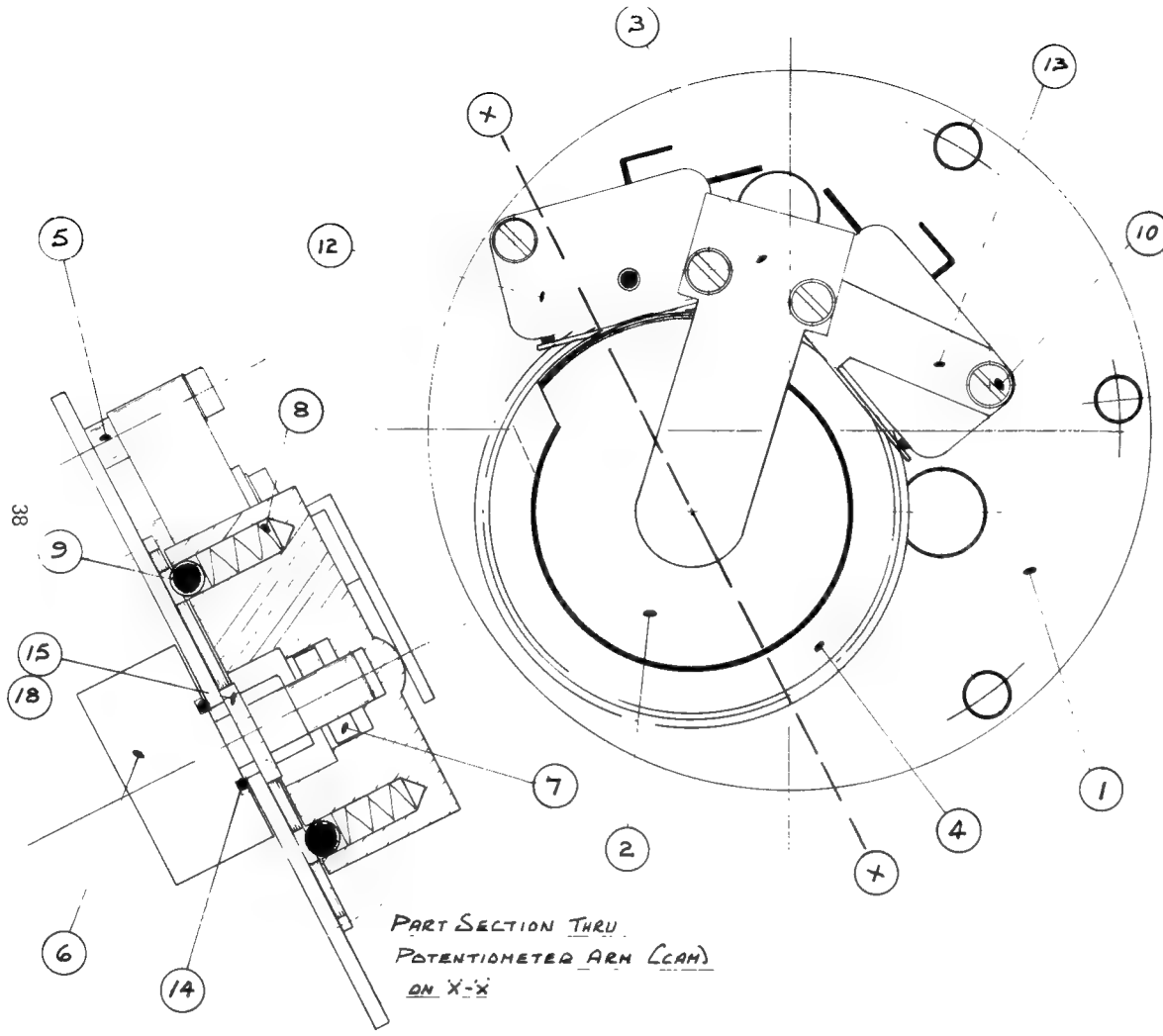


Fig 1

M.D.2.

1.	Case casting machined	1	D710510
2.	Drive belt casting	1	C760517
3.	Drive belt cover	1	D760518
4.	Electric motor 1/8 h.p. 12v.) Optional	1	X24517
5.	Electric motor 1/8 h.p. 24v.)	1	X24518
6.	Pulley 24 tooth 24XL037F	1	X24304
7.	Pulley 48 tooth 48XL037	1	X24408
8.	Belt 170XL037	1	X24410
9.	Slipping clutch yoke assy.	1	B710724
10.	Input shaft	1	A740307
11.	Bearing, ball, 1.5/16 o.d. x ½ bore	2	X24407
12.	Spacer, inter-bearing	1	A740304
13.	Worm	1	A710503
14.	Cam	2	A710802
15.	Cam spindle	1	A710801
16.	Clutch cable spring	1	A700513
17.	Clutch cable clamp	1	A700208
18.	Shaft output assy.	1	B710766
19.	Feedback plate assy.	1	B710511
20.	Oilite, 1¼ o.d. x 5/8 i.d. x ½ lg.	1	X24199
21.	Oilite, 1.3/8 o.d. x ¾ i.d. x ¾ lg.	1	X24200
22.	Gear 49 tooth spur	1	A710614
23.	Belleville washer	1	X20774
24.	Plate clamping	1	A710746
25.	Plate lid	1	B710735
26.	Screw ¼ BSF x 3/8 lg. Rd.Hd.	4	X23510
27.	Key 3/16 x 3/16 x 5/8 lg.	1	
28.	Washer 3/8 i.d. x .750 o.d. x .0312 thk.	2	X24229
29.	Block terminal	1	X20143
30.	Pin, Selok, 1/8 dia. x 1¼ lg.	1	X24201
31.	Spindle, worm wheel	1	A710722
32.	Washer, ½ i.d. x 1 o.d.	1	X20014
33.	Spacer, worm.	1	A740305
34.	Screw 3/16 BSW x ½" lg. Soc.Hd.Cap	4	X23168
35.	Screw 10-32 unf. 5/8 lg. Soc.Hd.Cap	3	X24521



PART SECTION THRU POTENTIOMETER ARM (CAM) ON X-X

FEEDBACK PLATE ASSEMBLY

	Feedback Plate Assembly comprising:	1	B710511
1	Feedback & Potentiometer Plate	1	A710512
2	Potentiometer Arm (Cam)	1	B710518/C
3	Cam Retaining Arm	1	A710513
4	Potentiometer Gear	1	A710516
5	Spacer - Microswitch	4	A701159
6	Potentiometer 5 K ohm Lin.	1	X24196
7	Dowel Pin	1	X24262
8	Spring - Compression	2	X24247
9	Ball Bearing	2	X23685
10	Washer - 6BA S'Proof	4	X20186
11	Screw - 6BA Ch.Hd. x $\frac{3}{4}$	4	X23486
12	Micro-switch	2	X17097
13	Actuator - Micro-switch	2	X20358
14	'O' Ring - R2037	1	X22327
15	Potentiometer Nut	1	A710517

Feedback and Limit Switch Operation (see page 38)

The function of the feedback and limit switch operation must be clearly understood.

The small gear wheel is attached to the output shaft, this gear turns the larger gear which drives the cam mechanism by two balls that locate into holes in this gear. The gear ratio is such that the cam will rotate 240° approximately to 5 turns of the output shaft, thus operating the potentiometer over the full length of its track. At the same time the cam will be rotated to wedge against the limit switch operating lever, when the limit switch operates it open circuits the relay coil supply and therefore the motor will not travel further in that direction.

In order that the output shaft can still be rotated further and prevent damage to the Feedback mechanism, the two balls held in position in the holes in the gearwheel by the springs in the cam will be driven out of position and the output shaft can continue to rotate. When the motor is reversed, the gear wheel with the holes in, to receive the balls, will rotate in the opposite direction but the cam will not move because it is wedged in position by the limit switch operating levers. Once the balls drop into the holes, the cam will then be driven out from the limit switch lever and function in the normal manner.

NOTE: the adjustment of this assembly is critical because if the cam does not wedge into position by the limit switch operating levers, it can be rotated by friction and not the balls dropping into the hole in the gear. This will cause malfunction of the Pilot because there is no longer any synchronisation between the feedback potentiometer and the output shaft.

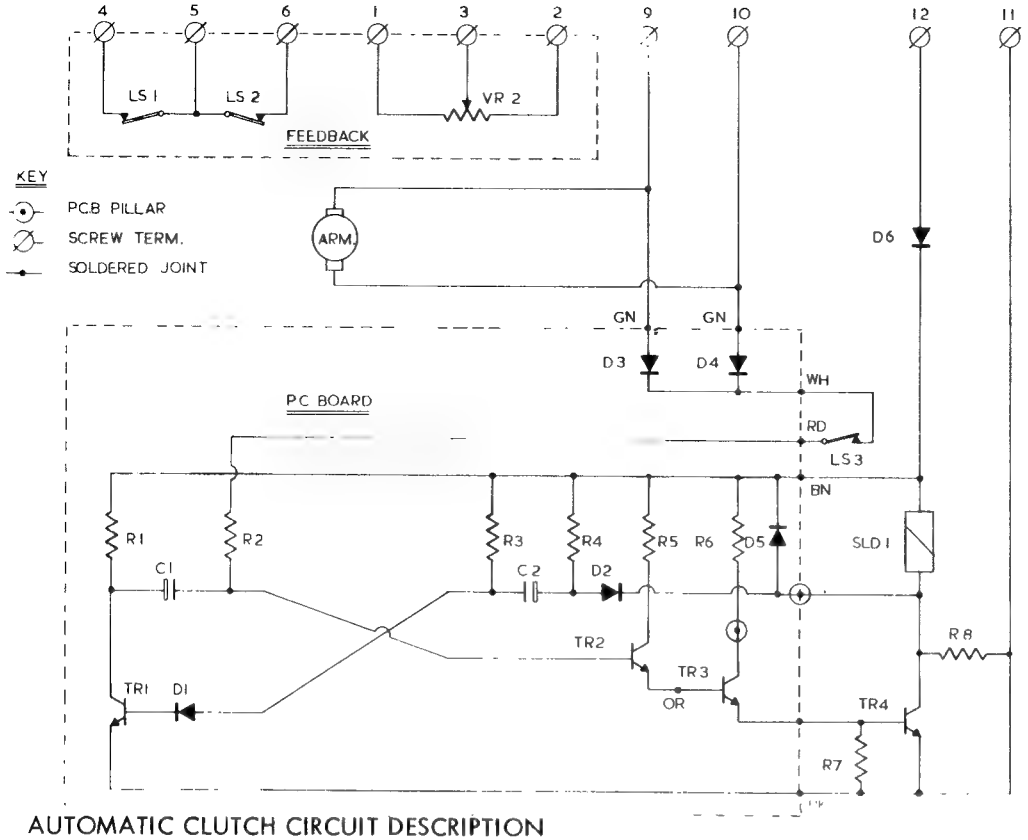
Feedback and Limit Switch Assembly (see page 38)

This assembly is removed by undoing the three fixing screws and can now be withdrawn from the main unit on its wired loom.

To dismantle Feedback plate assembly undo three screws and withdraw it from fabricated case. Remove screws holding Cam Retaining Arm (3) and withdraw cam being careful not to lose balls (9) and springs (8). Remove potentiometer drive pin (7), gear (4) and undo nut (15). The potentiometer can now be removed.

To re-assemble, position potentiometer with reference to the locating pip and tighten nut.

Replace gear over nut and position so that the ball accepting holes approximately bisect the angle of the limit switch arms with the hole nearest to the potentiometer spindle facing the limit switches. Insert potentiometer drive pin (7) and rotate spindle so that the pin is at 14° clockwise to the ball accepting hole. Replace balls (9) in accepting holes (hold with grease) and springs (8) in cam. Fit cam onto assembly and ensure that the springs mate with balls and the cam with the drive pin. The Cam should fit flush with gear. Replace cam retaining arm and fixing screws.



AUTOMATIC CLUTCH CIRCUIT DESCRIPTION

When the motor armature is energised either D3 or D4 will conduct taking R2 positive via normally closed micro-switch LS3. This will bias TR2, TR3 and TR4 'ON', thus energising the clutch solenoid SLD1. The plunger will pull in and the cam lever will open the micro-switch LS3 removing base bias from TR2 - TR4 thus de-energising the solenoid. The back EMF caused by SLD1 turning 'OFF' is limited by D5. Power resistor R8 provides sufficient current to hold the solenoid plunger home until the Control Unit function switch is changed to STANDBY or the YAW control turned to OFF.

Should the clutch not immediately engage, the TR4 will turn off after approximately 200 ms reducing the solenoid current to its holding value. After a period of approximately 2 seconds TR4 will again turn 'ON' for 200 ms. This pulsing action is produced by the multivibrator circuit comprising of TR1 - TR4 and limits the average current through the solenoid to a safe value.

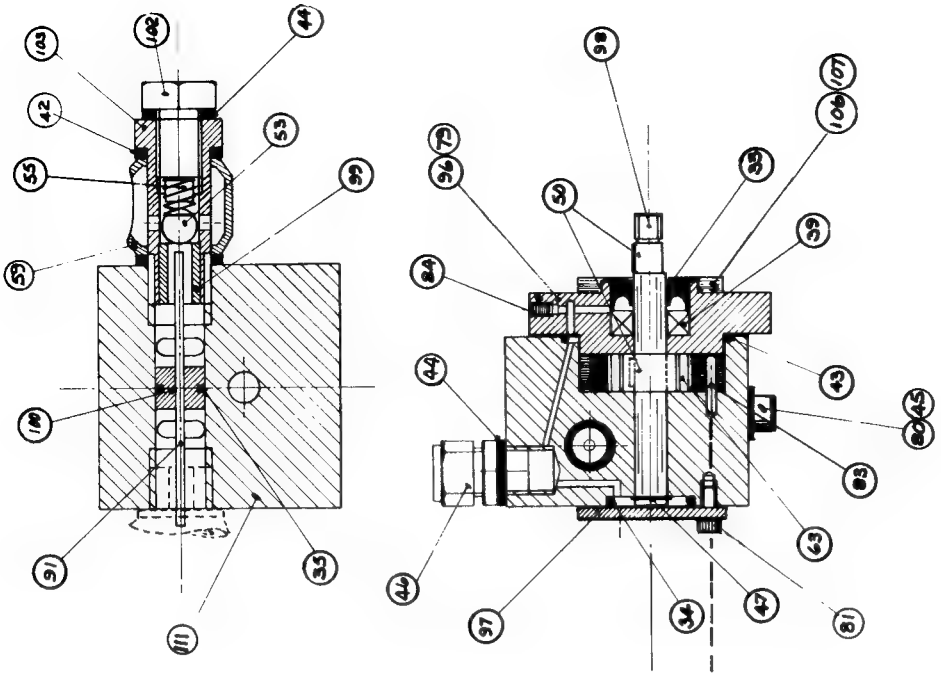
SETTING UP

Slacken solenoid fixing screws and depress solenoid plunger fully home. Adjust the solenoid position so that the cam roller is in the position shown on page 36 ensuring that the solenoid body is parallel to the chassis. Tighten fixing screws. With the solenoid fully depressed adjust the micro-switch plate so that approximately 0.020 inch (0.5 mm) of the micro-switch button is showing. Tighten fixing screws and check action by depressing plunger and ensuring micro-switch operates and the plunger travels fully home.

OPERATION CHECK

Connect Drive Unit to Control Unit, switch to DUTY and rotate TRIM control until motor turns. The clutch should engage within about two seconds. Ensure that the micro-switch has operated. Now check that with the motor turning and the clutch held dis-engaged, the solenoid pulls every two seconds.

With the above check successfully completed the Drive Unit assembly can now be fitted into the case.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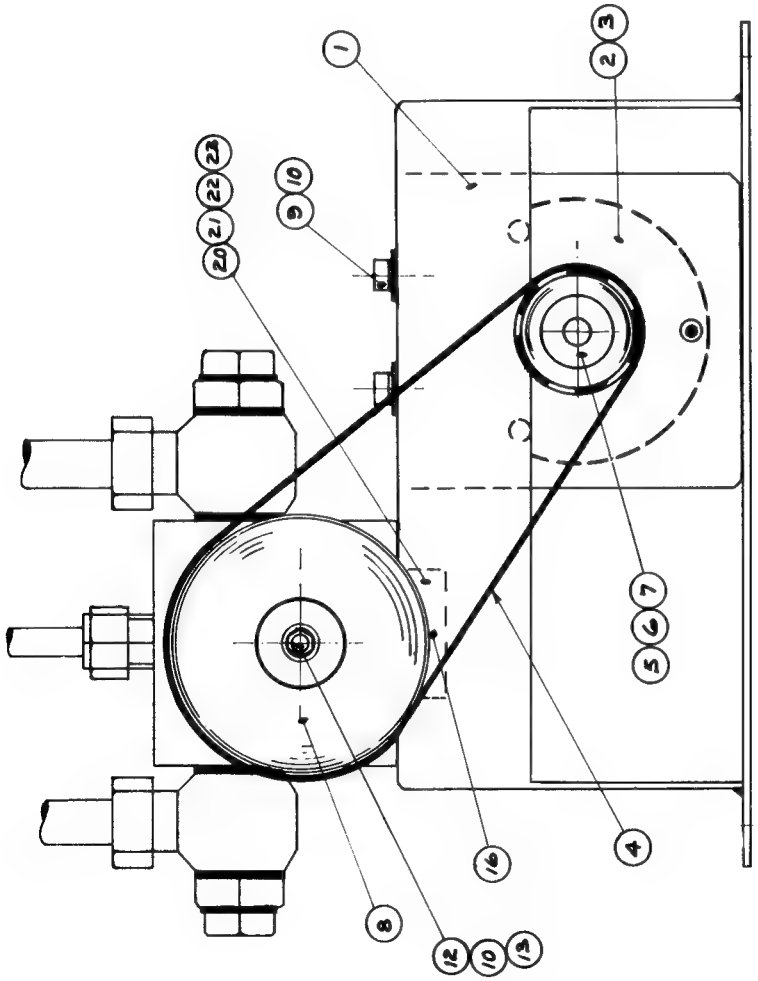
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DISMANTLING MD3

The motor is removed from the bracket (1) by undoing the two fixing screws (9) and disconnecting the motor wires from the terminal block (16) noting their connections. The pulley (7) can be withdrawn from the output shaft with the two grub screws loosened.

With the connecting pipes disconnected the pump is removed from the bracket by undoing the two fixing screws (80) underneath the pump body noting the oil seals (45) fitted under the screw heads. The pulley is removed from the pump shaft by removing the nut (12).

The pump is dismantled by removing the seal plate (97)and the circlip (47) from the pump shaft. The front cover fixing screws must now be undone allowing the cover and shaft to be withdrawn from the body. Extreme care must be taken to prevent damage to the Gerota assembly (63) noting that the rotor is a loose fit on the shaft to which it is keyed (50).

Should the Gerota assembly be found to be scored or damaged in anyway the complete pump unit must be returned to the factory for reconditioning.

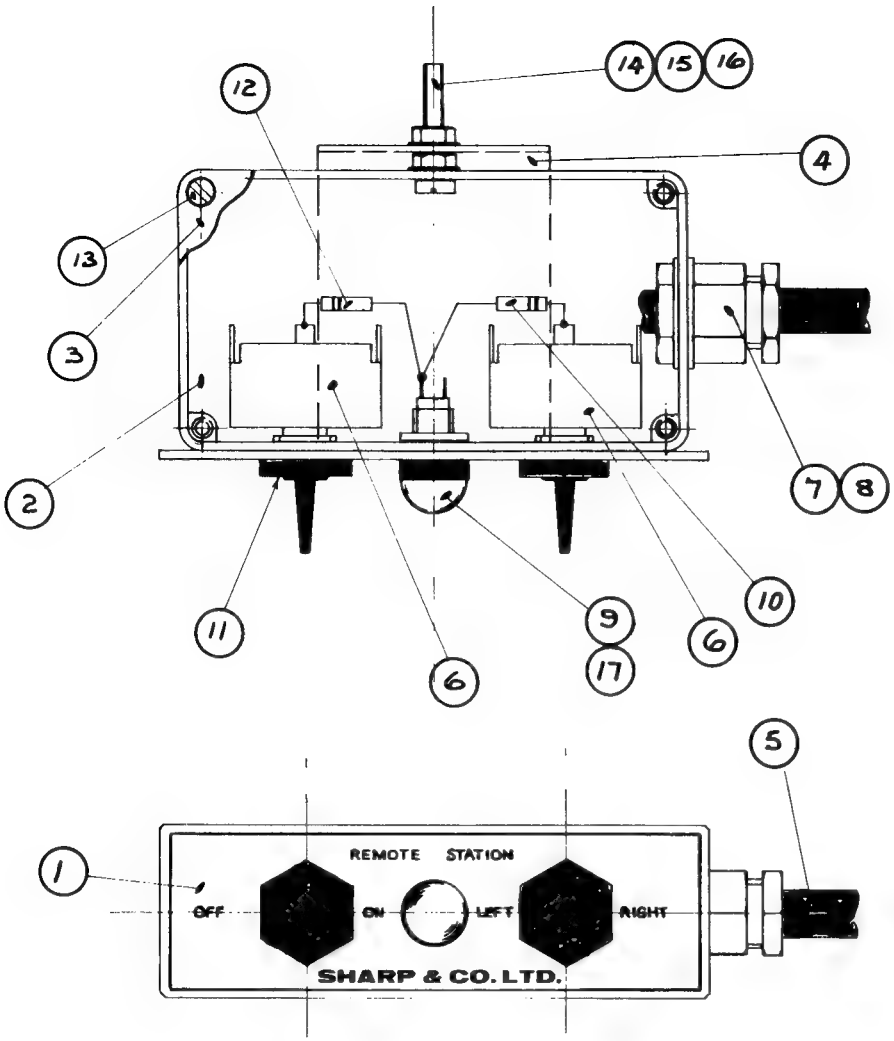
The Lock Valve piston (100) is removed from the body by undoing bolt (103) enabling it to be withdrawn. Check that the 'O' ring (35) is not damaged.

To remove the shaft from the cover (96) undo the screws (107) holding the seal retaining plate (106) and withdraw from the shaft with the oil seal (33). The shaft is now gently tapped out of the ball-race (39) taking care not to damage it.

Re-assembly is carried out in the reverse order, cleaning all components thoroughly in clean hydraulic oil. Ensure that all the oil rings and seals are replaced correctly and that the cover is correctly aligned with the grub screw (84) upper most, otherwise the entry to the make up pipe will be obstructed.

CAUTION Under no circumstances should the pump be run dry.

	Motor Bracket	1	B 760519
1	Bracket	1	C720503
2	Electric Motor 1/8 h.p. 12 volt.	1	X 24517
3	Electric Motor 1/8 h.p. 24 volt.	1	X 24518
4	Belt Drive Timing 150 XL	1	X24301
5	12T - 12 XL 037F 5/16 bore	1	X24302
6	18T - 18 XL 037F 5/16 bore	1	X24303
7	24T - 24 XL 037F 5/16 bore	1	X24304
8	48T - 48 XL 037F 7 mm bore	1	A720703
9	Screw ¼ UNF x 5/8 Lg.	2	X24330
10	Washer ¼ Plain	5	X20118
12	Nut ¼ BSF Hex. Full	1	X23359
13	Washer Spring S/C ¼ I/D	1	X20249
16	Terminal Block 3 way (cut from 12w)	1	X20143
20	Capacitor Supp. 0.1 mf.	2	X22829
21	Screw 6 BA Ch. Hd. x 5/8 Lg.	2	X20019
22	Nut 6BA Full	2	X23467
23	Washer 6BA S/Proof	2	X20186
33	Oil Seal	1	X24173
34	'O' Ring	1	X20570
35	'O' Ring	1	X22327
39	Ball Race	1	X24150
42	Seal	4	X17359
43	'O' Ring	1	X24153
44	Seal	3	X17406
45	Seal	4	X23526
46	Coupling	1	X23253
47	Circlip	1	X24154
50	1/16 Key	2	C.T.Stock
53	Ball	2	X24156
55	Spring	2	X22699
59	Banjo Set	2	X24160
63	Gerota Assembly	1	X24151
79	¼ Screw	4	X23108
80	5/16 Screw	2	X22993
81	4 BA Screw	3	X23691
83	Mills Pin	1	X24152
84	4BA Sets	1	X20950
91	Piston Spindle	1	A710413
96	Cover	1	A710405
97	Seal Plate	1	A710406
98	Pump Shaft	1	A710404
99	Bush	2	A710409
100	Piston	1	A710412
102	Screw Mod.	2	A710411
103	Bolt Mod.	2	A710410
106	Seal Ret.	1	A720504
107	Screw 6BA	4	X20391
111	Body	1	B710403



REMOTE STATION CONTROL

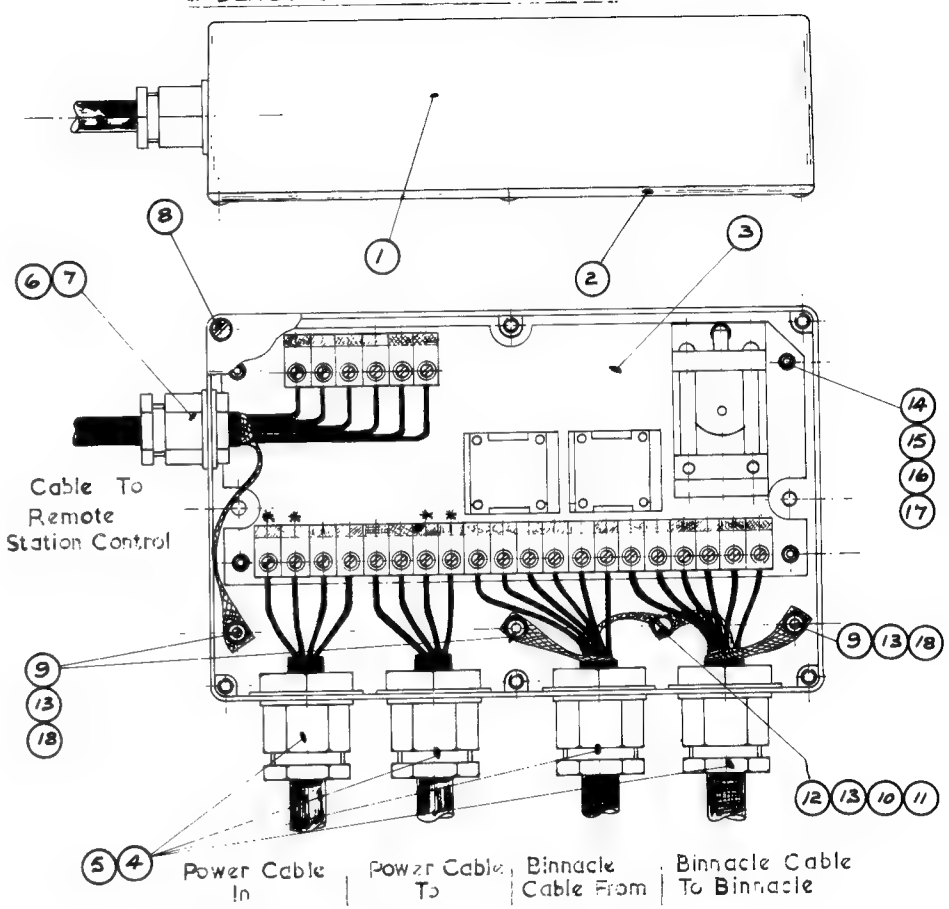
1	Panel Silk Screened	1	A730506
2	Die Cast Box M'cd.	1	B730504
3	Lid Die Cast	1	X21241
4	Mounting Bracket	1	A730507
5	Cable 6 core screened	20'	X23424
6	Switch S.P.C.O./C.O. 93F301B83	2	X24362
7	Gland 2SB 5/8 Conduit	1	X21698
8	Locknut Gland No. 19	1	X22897
9	Lamp Signal D674/1/Amber	1	X22425
10	Resistor 100 ohm $\frac{1}{2}$w. 2%	1	X21835
11	Rubber Sealing Boot SA9570/6	2	X24361
12	Resistor 1.5 K ohm $\frac{1}{2}$w. 2%	1	X22171
13	Screw 4BA R/Csk. Hd. x 3/8 Lg.	4	X24046
14	Screw 2BA C'Hd. x 3/4 Lg.	1	X23506
15	Nut 2BA Hex. Full	2	X23648
16	Washer 2BA S/Proof	2	X20161
17	Bulb 12v	1	X21743

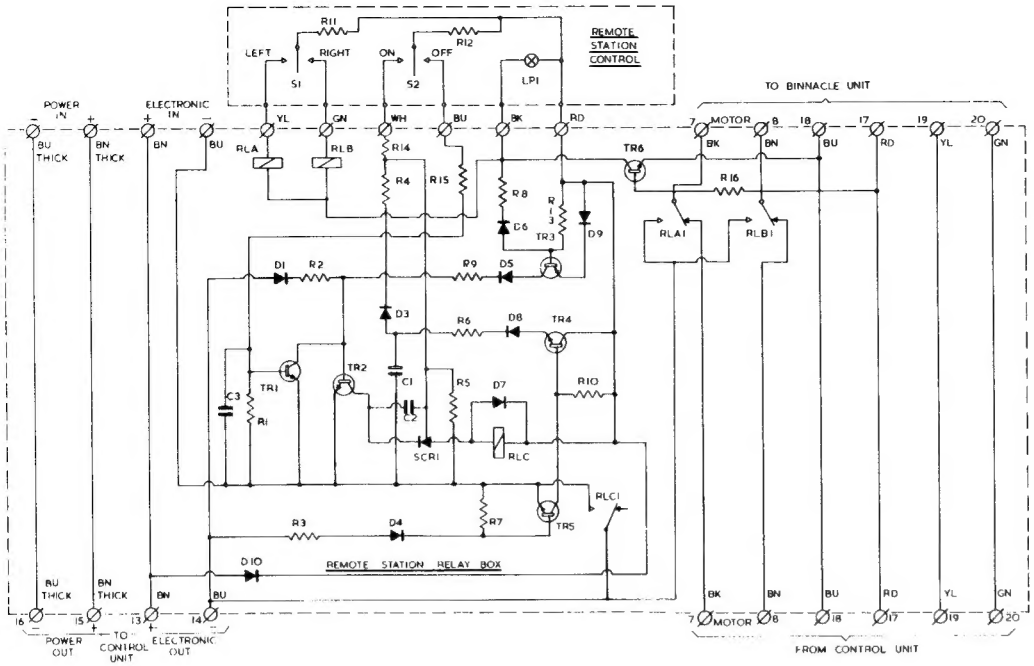
REMOTE STATION RELAY BOX

1	Box Die Cast M'cd.	1	B730509
2	Lid - Silk Screened	1	B730512
3	P.C.Board Assembly.	1	B730510
4	Locknut Gland No. 14	4	X22624
5	Gland Elkay 6A	4	X23346
6	Locknut Gland No. 19	1	X22897
7	Gland 23B	1	X21698
8	Screw 4BA Raised C'sk. x 3/8 L'g.	6	X24046
9	Screw 4BA C'sk. x 5/8 L'g.	3	X20990
10	Screw 4BA Ch.Hd. x 3/8 L'g.	1	X20607
11	Screw 4BA C'sk. x 3/8 L'g.	1	X20093
12	Pillar, Insulating	1	A21821/L
13	Washer 4BA Plain	8	X20369
14	Pillar, Spacing	4	A730515
15	Screw 6BA C'sk. x 3/8 L'g.	4	X20015
16	Washer 6BA S'Proof	4	X20186
17	Nut 6BA Hex. Full	4	X23467
18	Nut 4BA Hex. Full	6	X20176
19	Wiring	Ref	B730511
	Printed Circuit Board, Drilled	1	B730513
	Printed Circuit Board	1	B730514
	Resistor 10Kohm $\frac{1}{2}$w. 2%	6	X21831
	Resistor 4.7 Kohm $\frac{1}{2}$w. 2%	2	X22213
	Resistor 3.3 Kohm $\frac{1}{2}$w. 2%	2	X22214
	Resistor 220 ohm $\frac{1}{2}$w. 2%	1	X21919
	Capacitor 4 mfd. 10w.	1	X22560
	Diode IS 920	8	X22714
	Diode BYX 36-150	1	X23741
	Transistor BFY 50	1	X23627
	Transistor 2N 4062	1	X22713
	Transistor 2N 3709	3	X21937
	Thyristor TIC 44	1	X22712
	Relay 12v ITT	1	X24366
	Relay 6v Sub. Min.	2	X24342
	Terminal Block 12 way Type L1409 (Cut 6 way, 8 way, 12 way).	3	X20125
	Zener Diode IS3056A	1	X24405

WIRE COLOUR FOR COLOUR

* DENOTES HEAVY POWER CABLE





REMOTE STATION CIRCUIT DESCRIPTION

The Remote Station will only work when the Pilot is switched "on" at the main Control Unit.

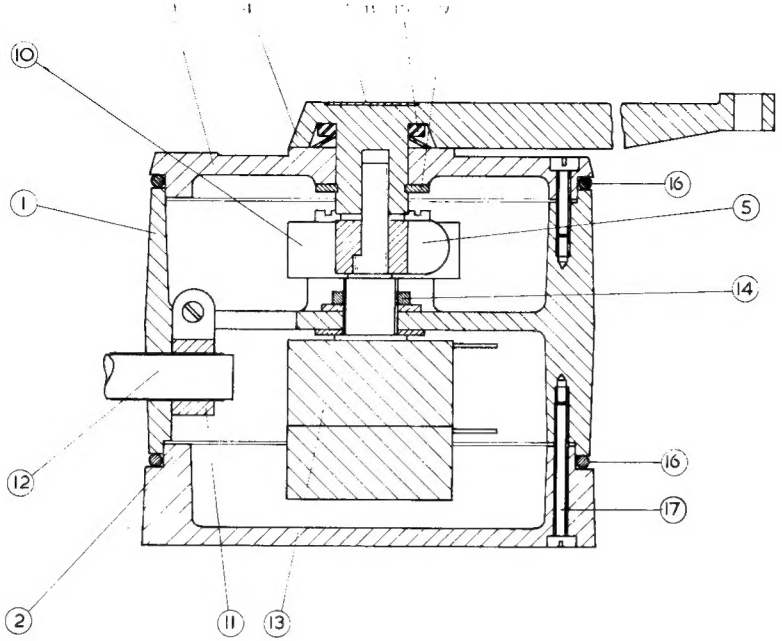
Switch S1 (8C) energises either RLA (9C) or RLB (8K), which switch power to the Binnacle motor via zener diode ZD1 (19K).

Switch S2 (12A) operates the electronics, which energise RLC (14L), the OFF/ON power relay.

With the Pilot operating, RLC is energised, SCR1 (12L) and TR2 (10J) both conducting. Bias flows via D9 (16E) through TR3 (15F), R4 (14F) and D5 (13F) to TR2 base. TR3 is a P.N.P. transistor, which is biased "on" via R8 (14E) and D6 (14D) to negative terminal No. 18. When the Pilot is switched off at the main Control Unit, terminal No. 18 is no longer negative and so TR3 and TR2 turn off and RLC becomes de-energised.

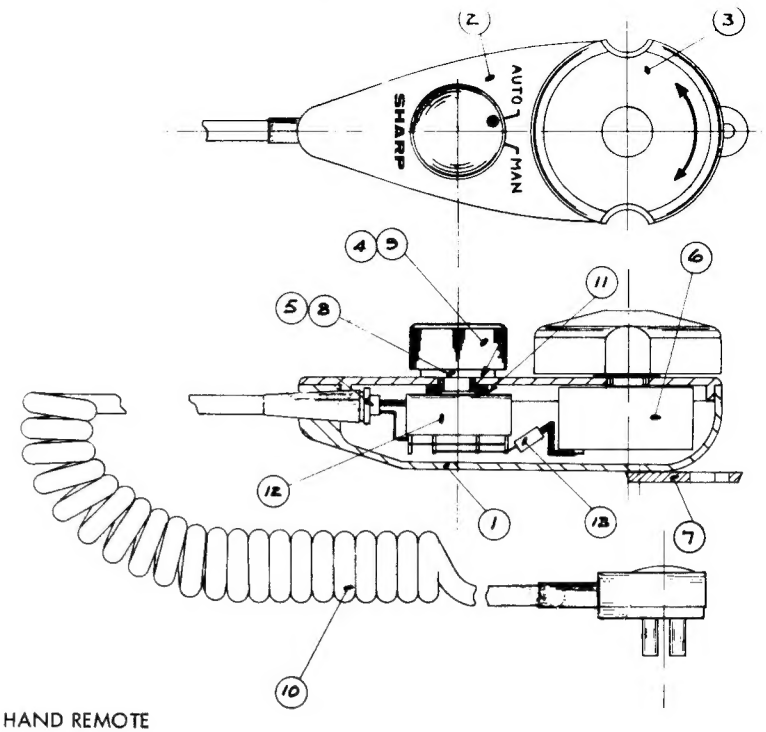
When S1A (26Q) on the Control Unit is switched on again, terminal No. 14 is positive and bias flows through R2 (8F) and D1 (9F) to turn TR2 'on'. Gate current flows from C1 (11J) via D3 (11G) and R9 (11D) to fire SCR1 and energise RLA.

When S2 is pressed to the 'off' position, bias flows through R12 (13A) to turn TR1 (8J) on and TR2 off. SCR1 stops conducting and RLC will de-energise. The Pilot will switch off and terminal 14 will become positive. Bias will flow through R2 and D1 (9F) to TR2 when the switch is released to the centre position. RLA will not energise until SCR1 fires, when the switch is pressed to the 'on' position and the gate is made positive.



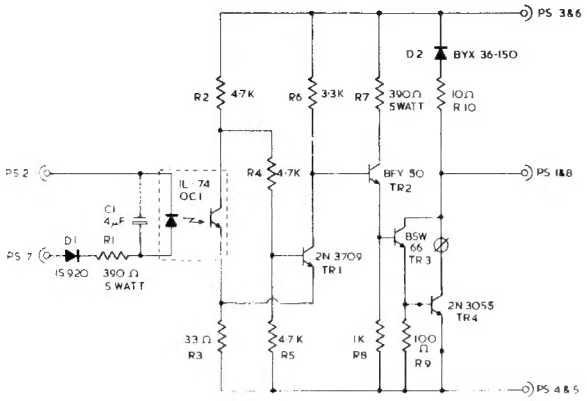
FEEDBACK

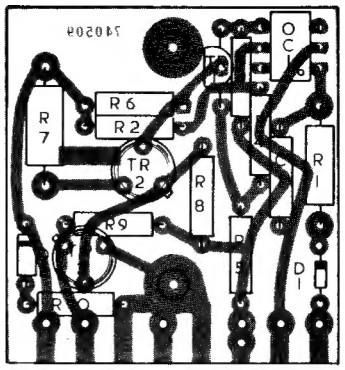
1	Body Moulding	1	B710922	
2	Base Moulding	1	B710924	
3	Cover Moulding	1	B710930	
4	Arm Moulding	1	B710928	
5	Pot. Arm Moulding	1	A710929	
7	Label - Normal	1	A711003	
8	Label - Inverted	1	A711004	
9	Circlip - 1400 - $\frac{1}{2}$"	1	X23584	
10	Microswitch (+ Actuator X20358)	2	X17097	LS2
11	Clamp - Cable 5/16 I/D x 3/8 W x 3	1	X24013	
12	Cable - 6 core 14/.0076 (Screened)	1M	X23424	
13	Potentiometer - 5 Kohm (to Sharp's Spec.)	1	A711132	
14	Nut. Lock 32 T.P.1. (supplied with Pot.)	1	X21019	
15	'V' Ring - V12A		X 24513	
16	'O' Ring - R3281		X 24514	
17	Screw - 6BA Ch.Hd. x 7/8 lg.		X 22376	



HAND REMOTE

1	Case - Moulding	1	A720806
2	Cover - Silk Screened	1	B721203
3	Knob - Moulding	1	A711130/A
4	Knob - Control	1	A721021
5	Potentiometer Sealing Nut	1	A721020
6	Potentiometer - 2 K Lin. A.B.W.2-43 X24275	1	A720258/B
7	Plate - Keyhole	1	A720527
8	Seal 'O' Ring - R2075 - P45 3/4 x 7/8 x 1/16	1	X22759
9	Screw 4BA Socket Set. St. St.	2	X24242
10	Cable 4-core Retractile	18"	X23980
11	Washer 3/8 Fibre	2	X21060
12	Switch - Rotary - 4 pole 2 way	1	X20994
13	Resistor - 1 Kohm $\frac{1}{2}$W. 2% TR5	1	X21827





CIRCUIT DESCRIPTION

Pin PS7 is connected to the electronics +ve supply via the limit switches and the Control Unit function switch. Pin PS2 is connected to the collectors of the output transistors on the main printed board. When an output transistor turns 'on' its collector goes negative taking the cathode of the light emitting diode in the optical coupler OC1 negative. The anode is held positive by D1, which provides polarity protection and R1 which limits the LED current. C1 is included to de-couple any A.C. signals that may be present.

A current flowing through the LED causes it to emit light which is sensed by the opto-transistor in OC1 turning it 'on' and thus providing complete electrical isolation between the electronic and power circuits. With the transistor 'on' the junction of R2 and R4 is taken negative turning 'off' TR1 whose collector goes positive turning 'on' TR2 and in turn TR3 and TR4. R3 is included in the circuit so that OC1 transistor and TR1 have a Schmitt action to eliminate the possibility of the final transistor not turning 'on' fully.

D2 and R10 are included for back emf suppression of the inductive spool valves.

COMPONENTS

Circuit Ref:	Description	X No.	PCB Ref
R1	390 ohm 5 watt Resistor	X20202	9
R2	4.7 K ohm ½ watt Resistor	X22213	10
R3	33 ohm ½ watt Resistor	X22219	11
R4-R5	4.7 K ohm ½ watt Resistor	X22213	10
R6	3.3 K ohm ½ watt Resistor	X22214	12
R7	390 ohm 5 watt Resistor	X20202	9
R8	1 K ohm ½ watt Resistor	X21827	13
R9	100 ohm ½ watt Resistor	X21835	14
R10	10 ohm ½ watt Resistor	X 21935	15
C1	4 mf 10v. Capacitor	X22560	5
D1	IS920 Diode	X22714	3
D2	BYX36-150 Diode	X23741	4
TR1	2N3709 Transistor	X21937	6
TR2	BFY50 Transistor	X23627	7
TR3	BSW66 Transistor	X24435	8
TR4	2N3055 Transistor	X22488	
OC1	1L-74 Opto-Coupler	X24434	2
PS1-8	Octal Plug BCM8/USP	X24440	
	Chassis Silk Screened	A740613	
	Spacer 2 off	A740606	
	Printed Circuit Board	A740603	1

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